YANMAR

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SERVICE MANUAL

MARINE DIESEL ENGINE

2GMFY, 3GMFY

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MODELS 2GMFY, 3GMFY

FOREWORD

This service manual has been compiled for engineers engaged in sales, service, inspection and maintenance. Accordingly, descriptions of the construction and functions of the engine are emphasized in this manual while items which should already be common knowledge are omitted.

One characteristic of a marine diesel engine is that its performance in a vessel is governed by its applicability to the vessel's hull construction and its steering system.

Engine installation, fitting out and propeller selection have a substantial effect on the performance of the engine and the vessel. Moreover, when the engine runs unevenly or when trouble occurs, it is essential to check a wide range of operating conditions—such as installation on the hull and suitability of the ship's piping and propeller—and not just the engine itself. To get maximum performance from this engine, you should completely understand its functions, construction and capabilities, as well as proper use and servicing.

Use this manual as a handy reference in daily inspection and maintenance, and as a text for engineering guidance.

Models 2GMFY·3GMFY

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CHAPTER 1

GENERAL

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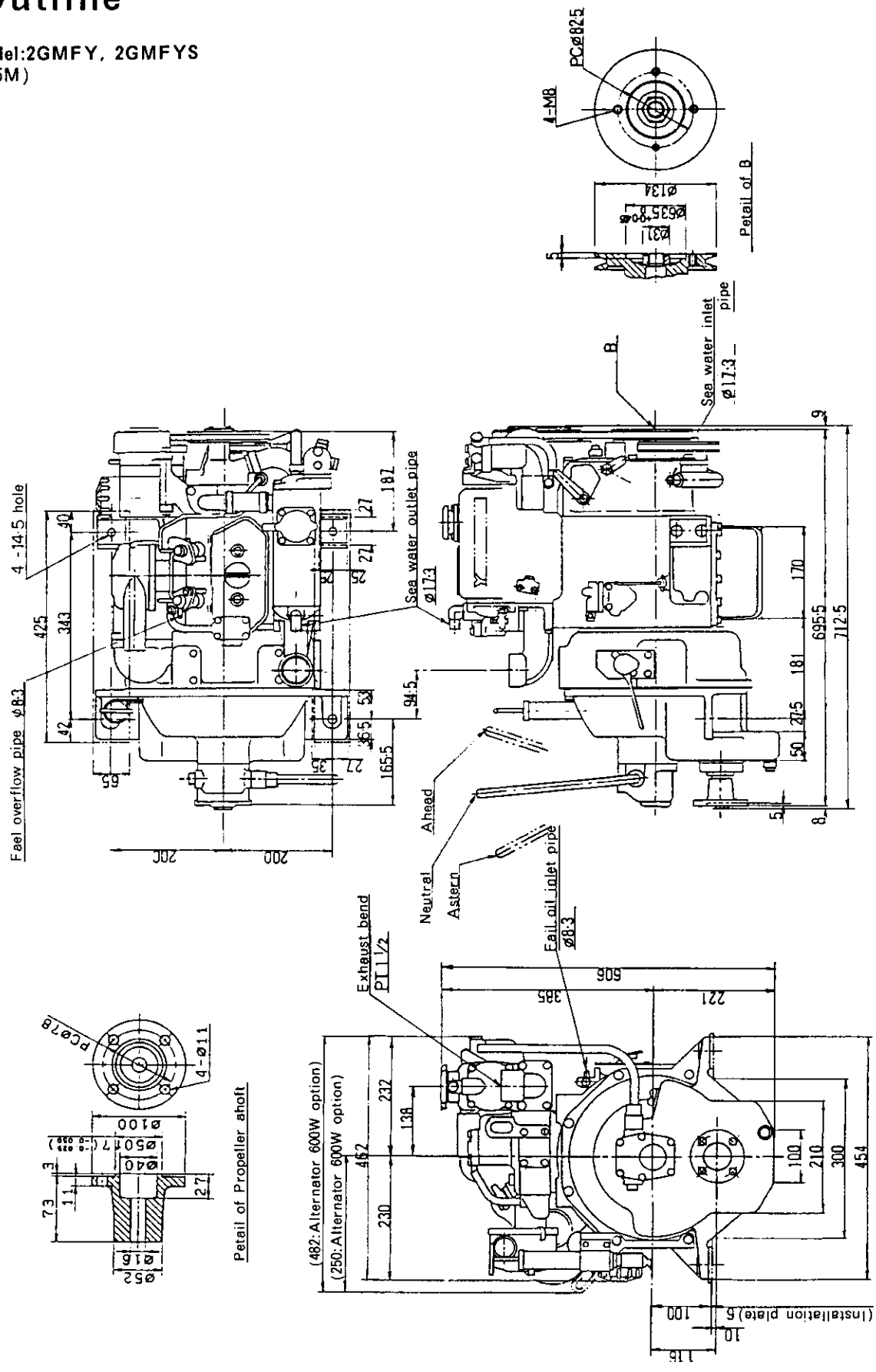
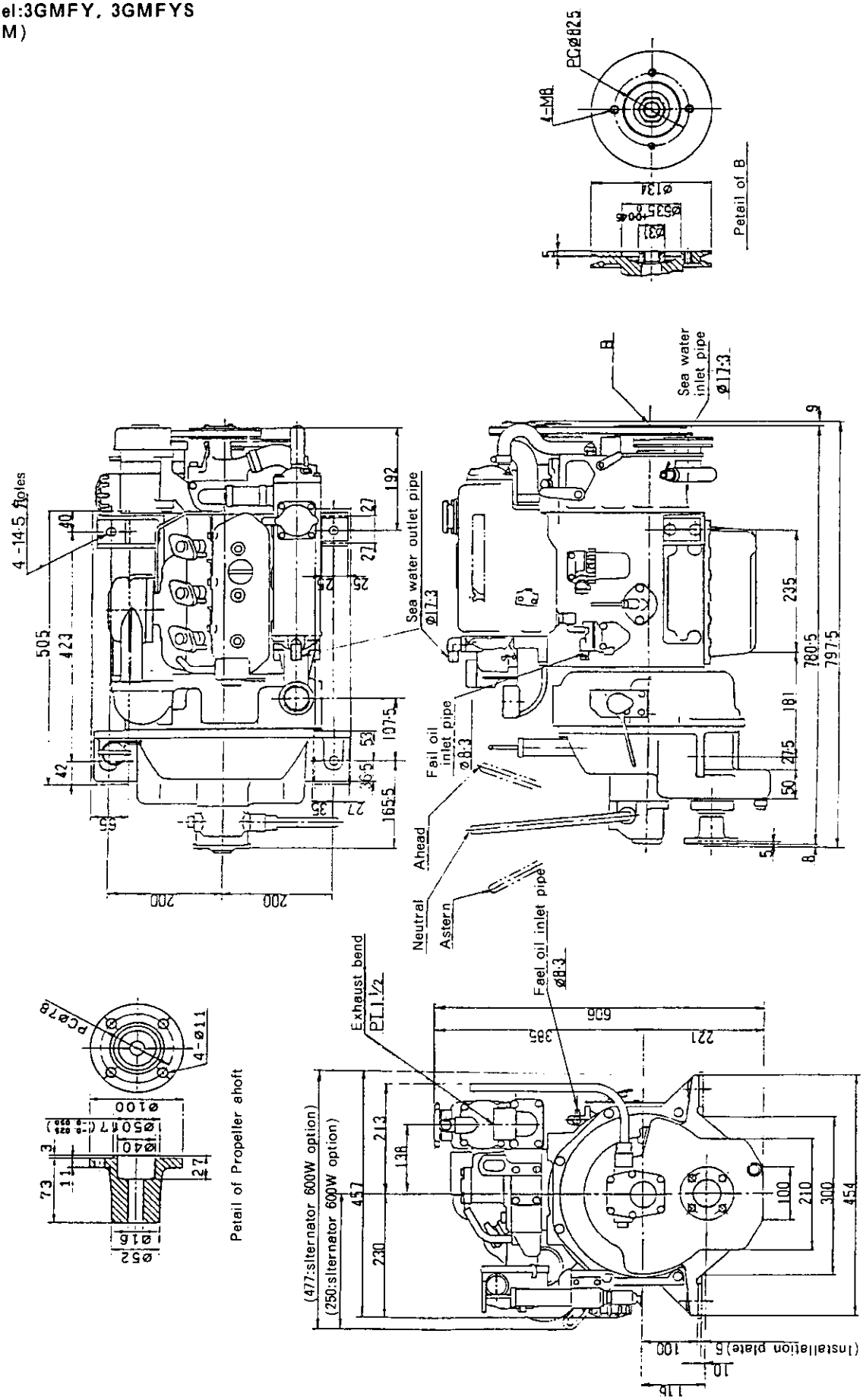
1. Outline

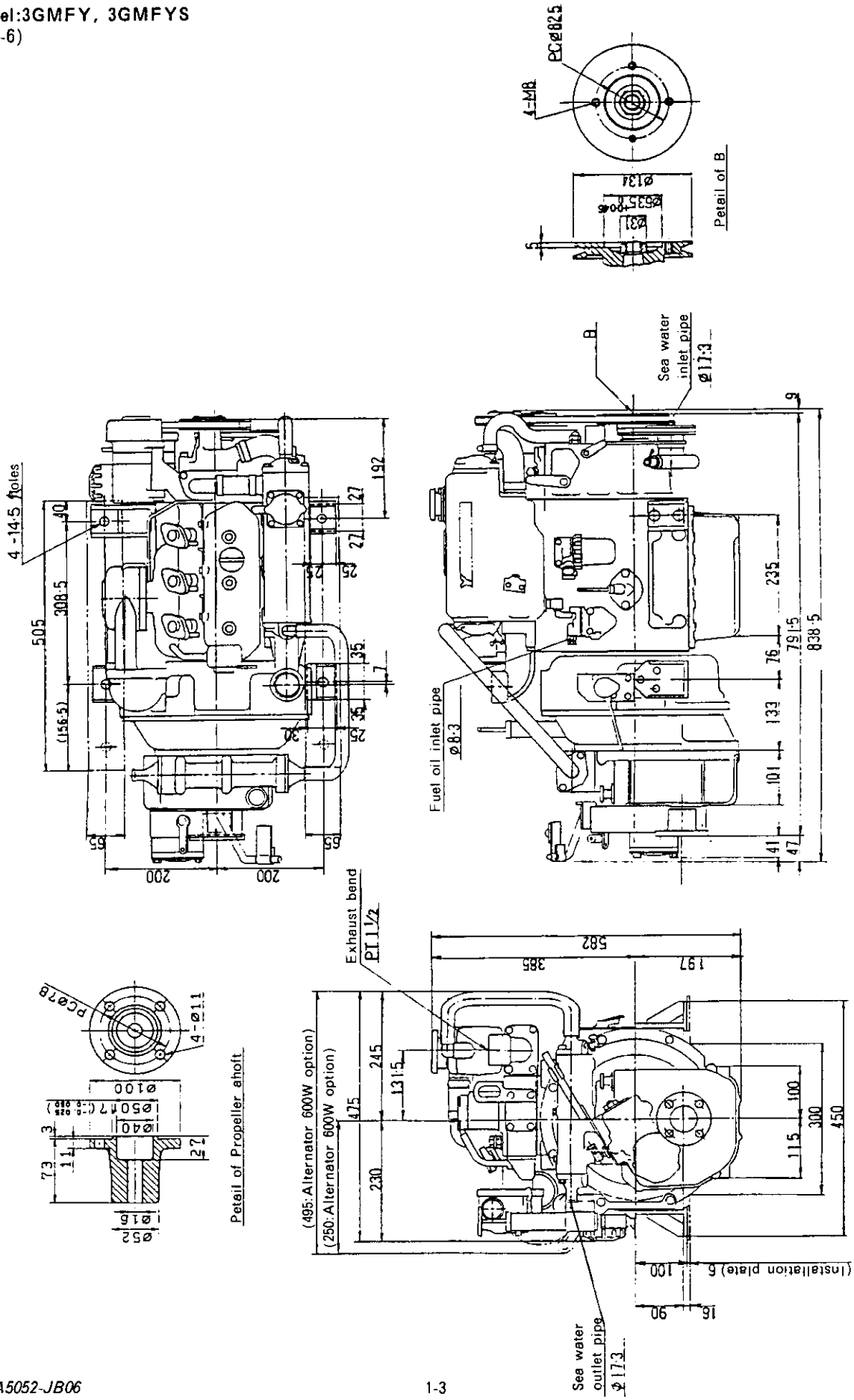
1-1. Model:2GMFY, 2GMFYS (Y-5M)



1-2. Model:3GMFY, 3GMFYS
(Y-5M)



1-3. Model:3GMFY, 3GMFYS
(YX-6)



2. Specifications

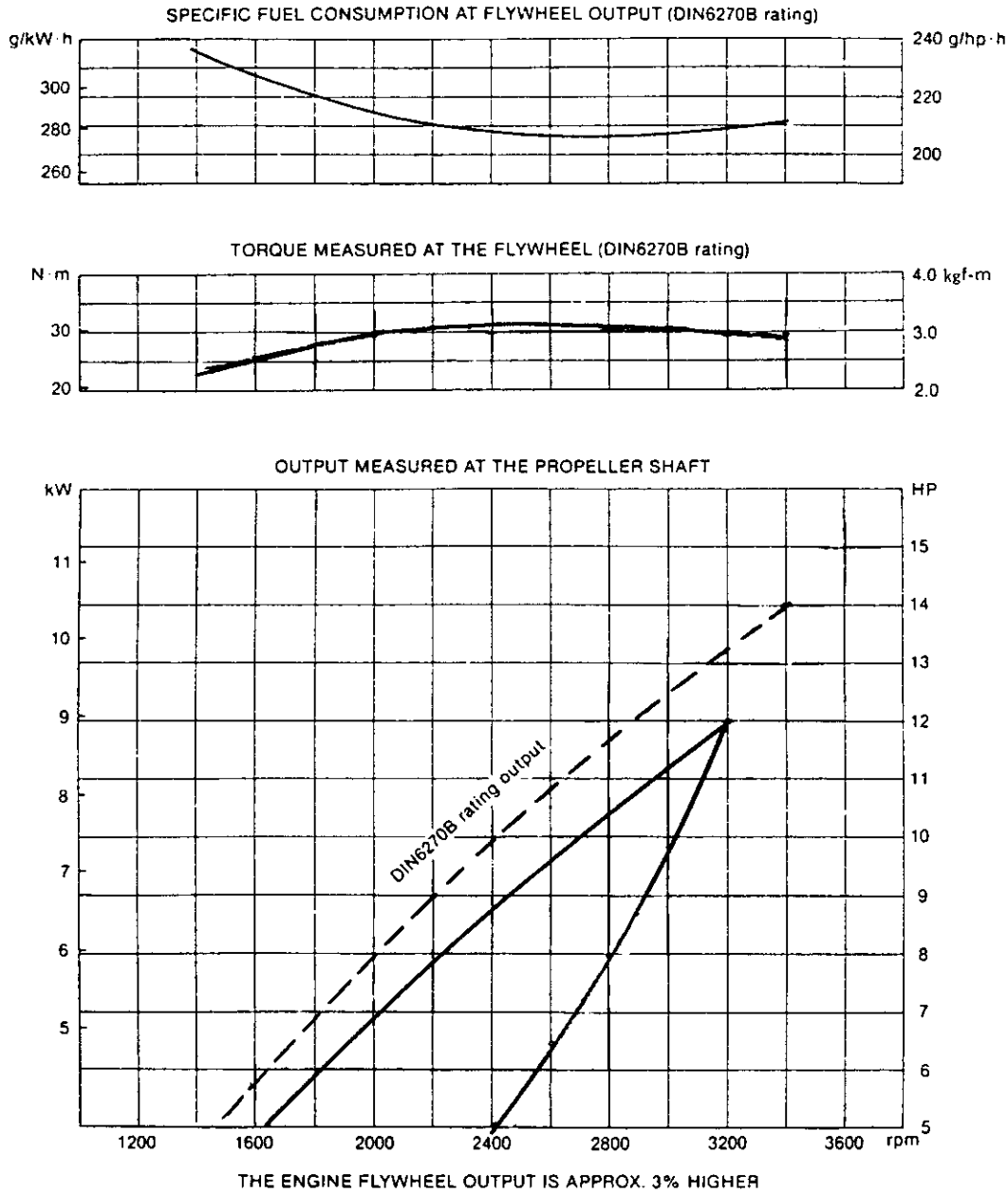
Model			2GMFY		3GMFY					
Type			Vertical 4-cycle water cooled diesel engine							
Combustion chamber			Swirl pre-combustion chamber							
Number of cylinders			2		3					
Bore × stroke		mm	72 × 72							
Displacement		ℓ	0.586		0.879					
Continuous rating output (DIN6270A)	Output/Crankshaft speed	HP/rpm	12/3200		18/3200					
	Brake mean effective pressure	kgf/cm²	5.76							
	Piston speed	m/sec.	7.68							
One hour rating output (DIN6270B)	Output/crankshaft speed	HP/rpm	14/3400		21/3400					
	Brake mean effective pressure	kgf/cm²	6.32							
	Piston speed	m/sec.	8.16							
Compression ratio			23.0							
Fuel injection timing (FID)		degree	bTDC15±1		bTDC18±1					
Fuel injection pressure		kgf/cm²	180±5							
Main power take off			at Flywheel side							
Front power take off			at Crankshaft V-pulley side							
Direction of rotation	Crankshaft		Counter-clockwise viewed from stern							
	Propeller shaft (A head)		Clockwise viewed from stern							
Cooling system			Fresh water cooling							
Lubrication system			Complete enclosed forced lubrication							
Starting system			Electric and/or manual		Electric					
Clutch	Model		Y-5M		Y-5M		YX-6			
	Type		Mechanical clutch		Mechanical clutch		Hydraulic multidisc clutch			
	Reduction ratio (Ahead/Astern)		2.10/1.80	3.04/2.48	2.10	3.04	2.03	2.55	2.96	3.48
	Propeller speed DINA rating (Ahead/Astern)	rpm	1521	1051	1521	1051	1577	1254	1081	920
	Lubricating oil capacity	ℓ	0.5		0.5		1.2			
	Clutch weight	kg	28		28		22			
Dimensions	Overall length	mm	712.5		797.5					
	Overall width	mm	482		477					
	Overall height	mm	606		606					
Lubricating oil capacity (rake angle 8°)	Total	ℓ	2.8		3.7					
	Effective	ℓ	1.5		2.6					
Engine weight with clutch (dry)		kg	142		161		155			

3. Principal Construction

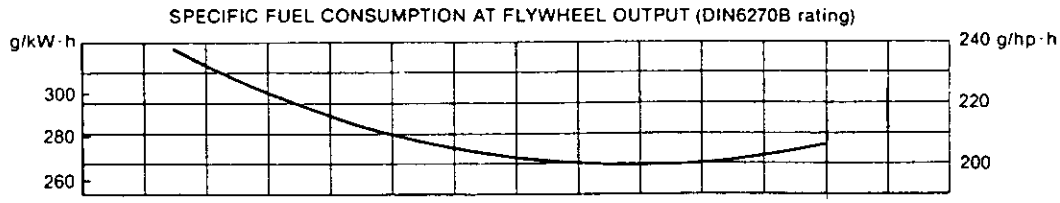
Engine model		2GMFY	3GMFY			
Group	Part	Construction				
Engine block	Cylinder block	Integrally-cast water jacket and crankcase				
	Cylinder liner	Sleeveless	Dry sleeve type			
	Main bearing	Metal housing type				
	Oil sump	Oil pan				
Intake and exhaust systems and valve mechanism	Cylinder head	Integrated type cylinders				
	Intake and exhaust valves	Poppet type, seat angle 90°				
	Exhaust manifold					
	Exhaust silencer					
	Valve mechanism	Overhead valve push rod, rocker arm system				
	Intake silencer	Round polyurethane sound absorbing type				
Main moving elements	Crankshaft	Stamped forging				
	Flywheel	Attached to crankshaft by flange, with ring gear				
	Piston	Oval type				
	Piston pin	Floating type				
	Piston rings	2 compression rings, 1 oil ring				
Lubrication system	Oil pump	Trochoid pump				
	Oil filter	Full-flow cartridge type, paper element				
	Oil level gauge	Dipstick				
Cooling system	Water pump	Rubber impeller type A				
	Thermostat	Wax pellet type				
Fuel system	Fuel injection pump	YPFR-0707-2	YPFR-0707			
	Fuel injection valve	530 semi-throttle valve				
	Fuel strainer	Filter paper				
Governor	Governor	Centrifugal all-speed mechanical type				
Starting system	Electric	Pinion ring gear type starter motor				
	Manual	Camshaft starting				
Electrical system	Charger	Alternator (with built-in IC regulator)				
Reduction reversing	Reduction gear					
Clutch system	Clutch					

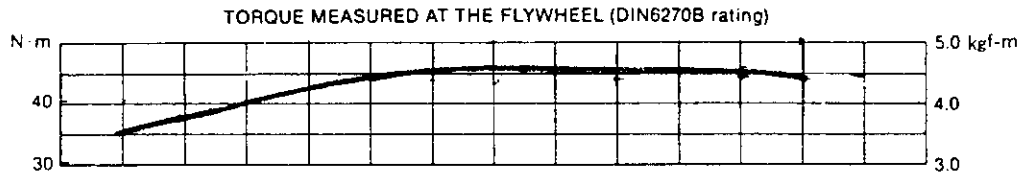
4. Performance Curves

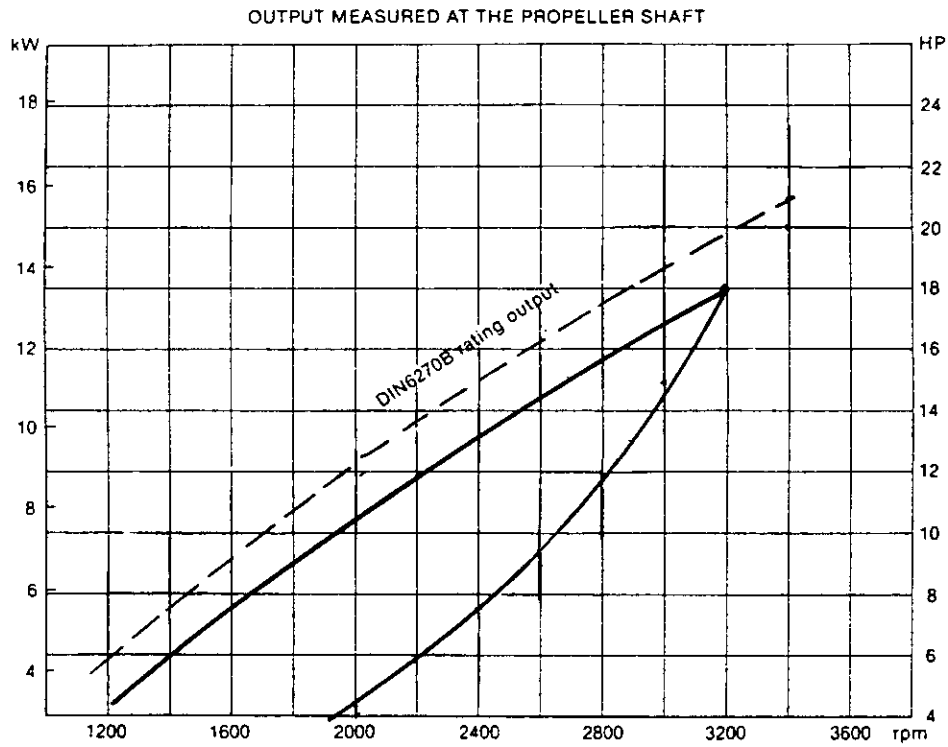
4-1. 2GMFY



4-2. 3GMFY



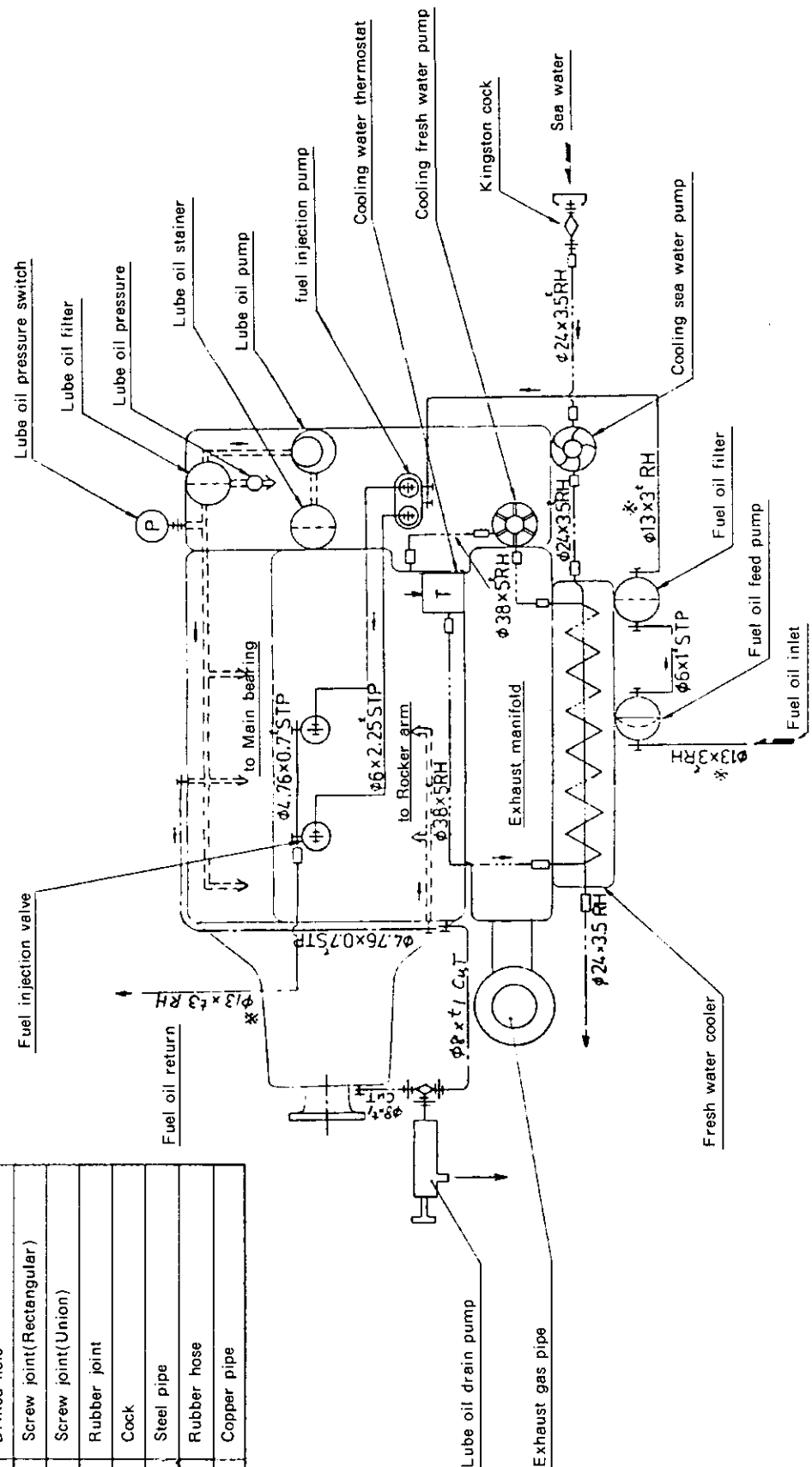




THE ENGINE FLYWHEEL OUTPUT IS APPROX. 3% HIGHER

5. Piping layout

5-1. 2GMFY



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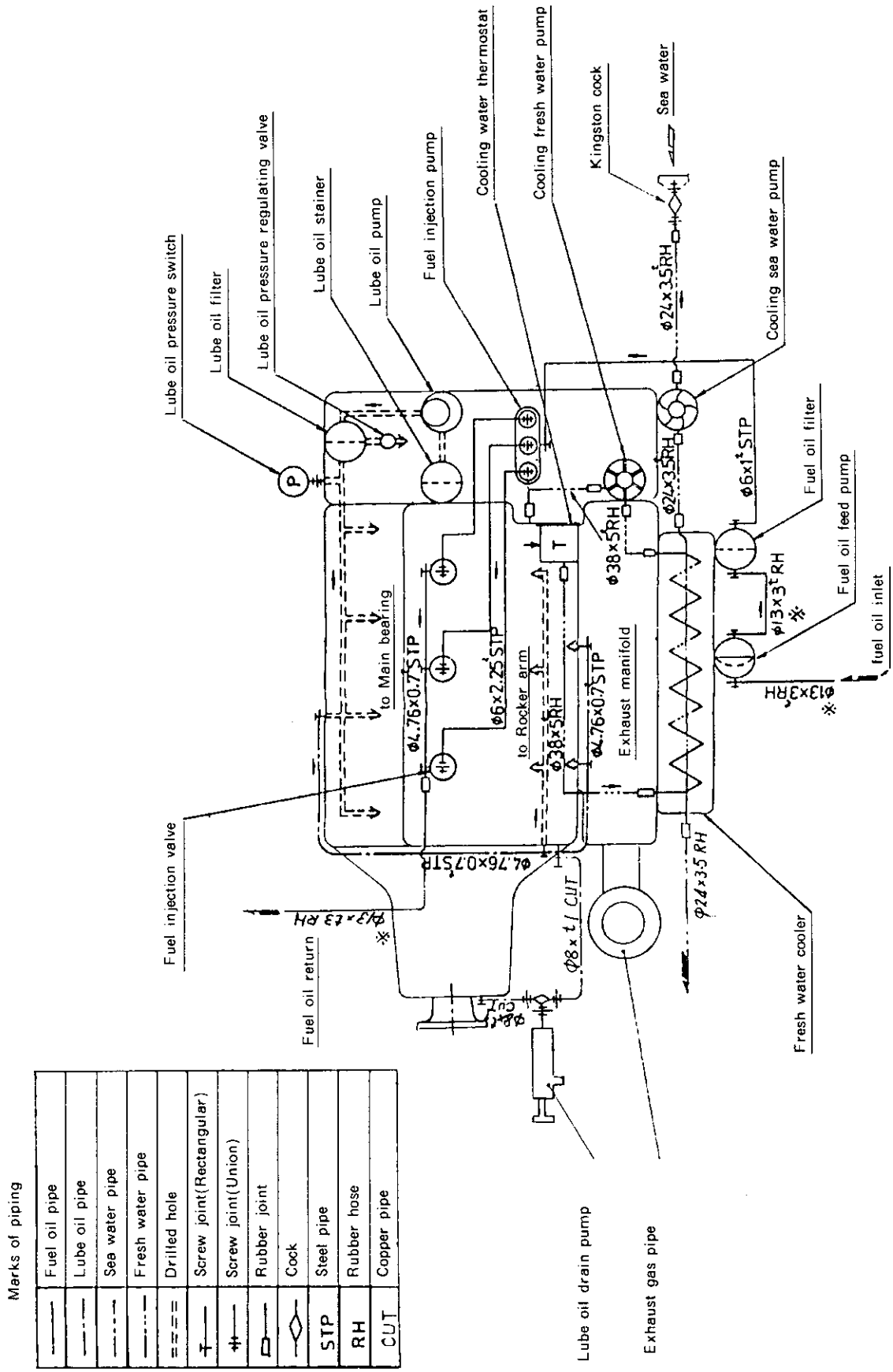
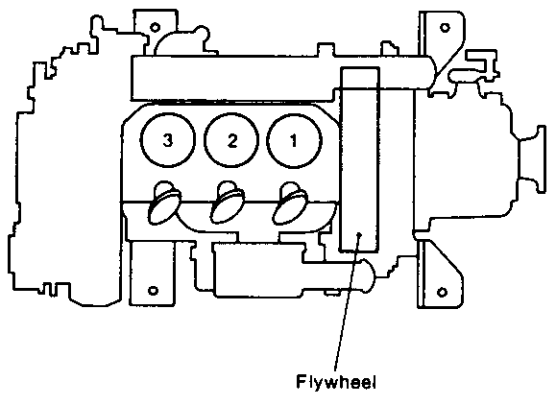
5-2. 3GMFY


Lube oil pressure switch
Lube oil filter
Lube oil pressure regulating valve
Lube oil stainer
Lube oil pump
Fuel injection pump
Cooling water thermostat
Cooling fresh water pump
Kingston cock
Sea water
Cooling sea water pump
Fuel oil filter
Fuel oil feed pump
Fuel oil inlet
Fuel injection valve
Fuel oil return
Lube oil drain pump
Exhaust gas pipe
Fresh water cooler
to Main bearing
to Rocker arm
Exhaust manifold
Marks of piping
Fuel oil pipe
Lube oil pipe
Sea water pipe
Fresh water pipe
Drilled hole
Screw joint(Rectangular)
Screw joint(Union)
Rubber joint
Cock
Steel pipe
Rubber hose
Copper pipe
STP
RH
CUT

6. Cylinder Number

The cylinder numbers of the 2 cylinder engine (2GMFY) and 3 cylinder engine (3GMFY) described in this manual are designad as follows.



(1) The sequence of cylinder numbers is given as No. 1, No. 2 and No. 3 starting from the flywheel side.
(2) These cylinder numbers are consistently used for devices and parts connected with the cylinder head and valve moving mechanism. However, please note that items related to the fuel injection pump do not correspond to the numbering of the cylinders.

CHAPTER 2

BASIC ENGINE

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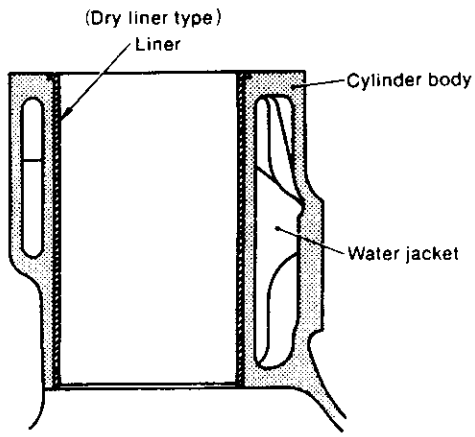
1. Cylinder Block

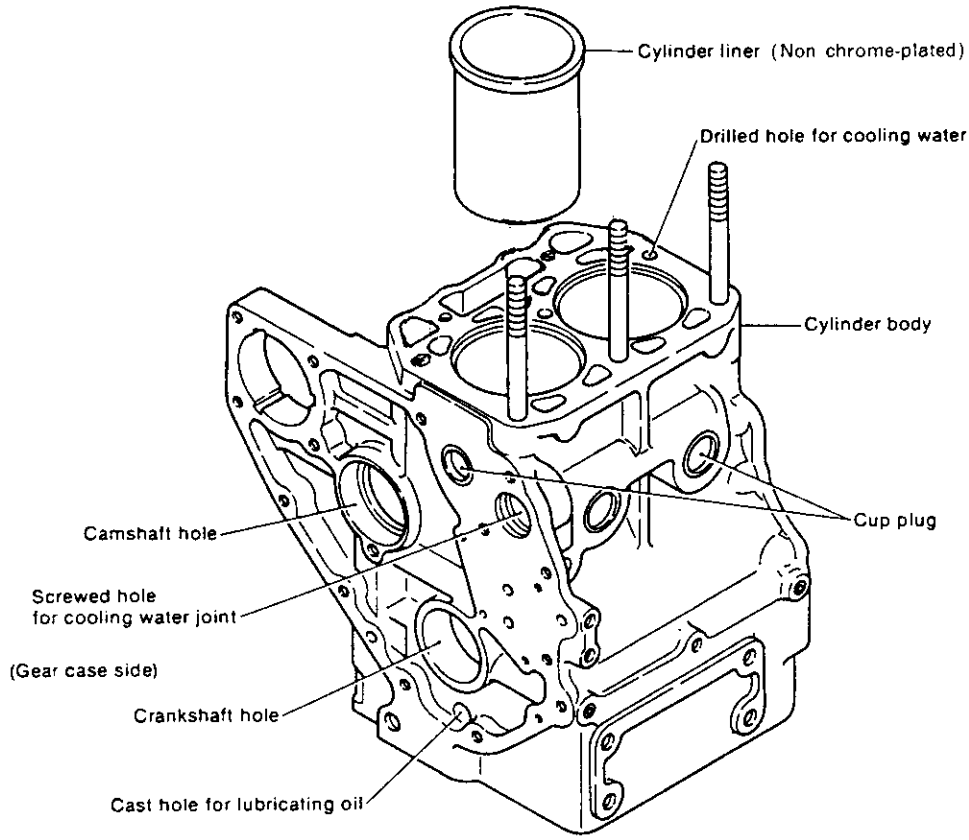
1-1 Construction

For models GM Series engine, the dry liner construction is adopted in which the cooling water does not come into derect contact with the external surface of the liner.

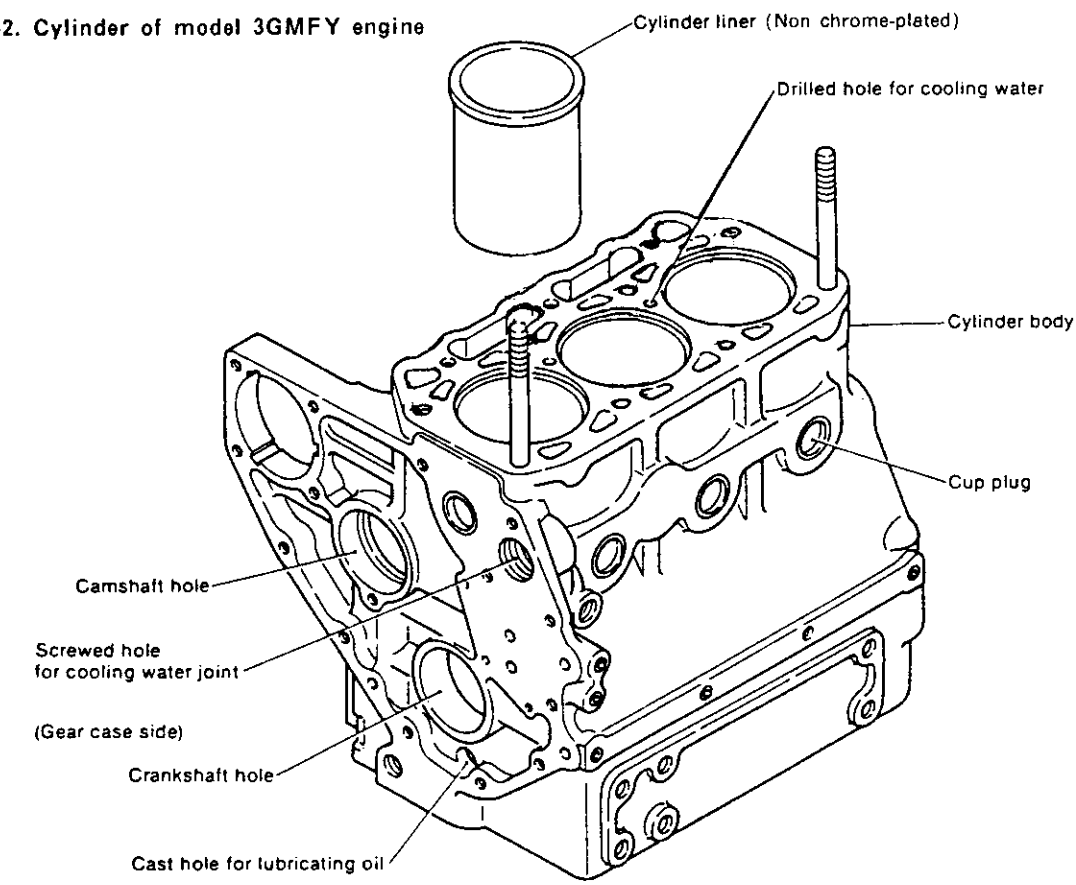


The cylinder block is a high-quality cast iron casting, with integral cylinders and deep skirt crankcase construction. As a result of stress analyses, the shape and thickness of each part has been optimized, and special ribs employed which not only increase the strength and rigidity of the block, but also reduce noise.

1-1-1. Cylinder of model 2GMFY engine



1-1-2. Cylinder of model 3GMFY engine



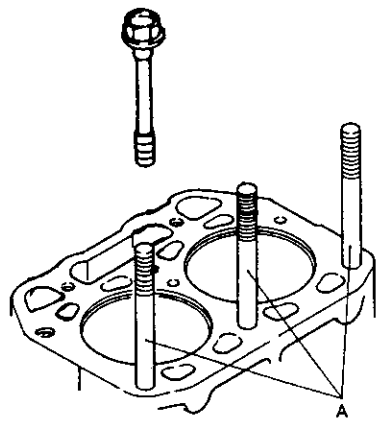
1-2 Cylinder block inspection

1-2.1 Inspecting each part for cracks

If the engine has been frozen or dropped, visually inspect it for cracks and other abnormalities before disassembling. If there are any abnormalities or the danger of any abnormalities occurring, make a color check.

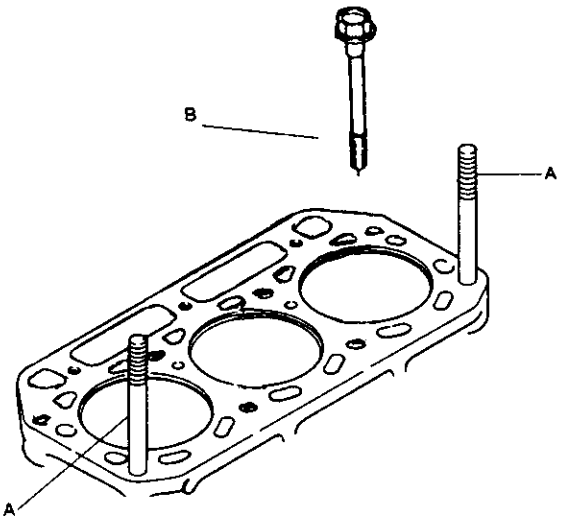
1-2-2. Cylinder head stud bolts

Check for loose cylinder head bolts and for cracking caused by abnormal tightening, either by visual inspection or by a color check.
Replace the cylinder block if cracked.



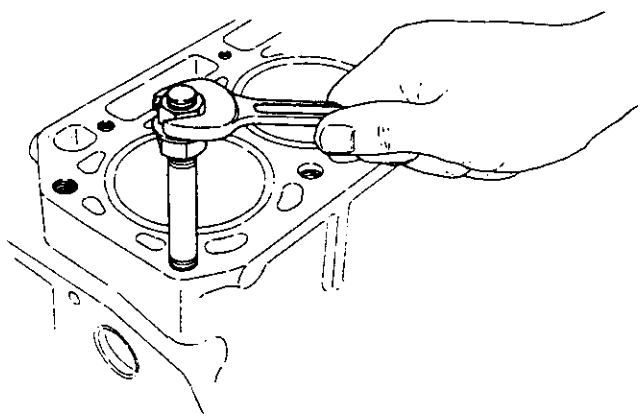
2GMFY

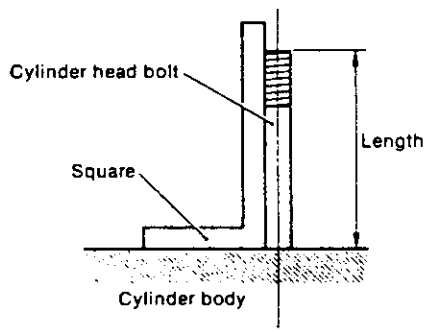
Bolt diameter		M12 (0.4724in.)
Length	A	96mm (3.7795in.)
	B	82mm (3.2283in.) ×3
Tightening torque		4.0 ~ 4.5 kg-m (28.9 ~ 32.5 ft-lb)



3GMFY

Bolt diameter		M12 (0.4724in.)
Length	A	96mm (3.7795in.) × 2
	B	82mm (3.2283in.) × 6
Tightening torque		4.0 ~ 4.5 kgf-m (28.9 ~ 32.5 ft-lb)



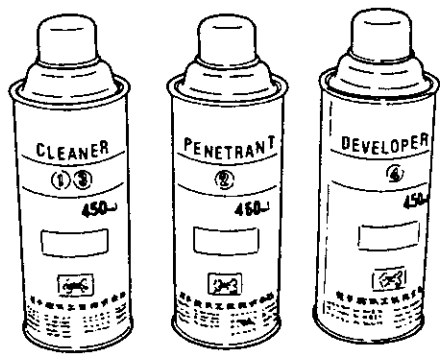


1-2.3 Oil and water passages

Check the oil and water passages for clogging and build-up of foreign matter.

1-2.4 Color check flaw detection procedure

(1) Clean the inspection point thoroughly.
(2) Procure the dye penetration flaw detection age agent comes in spray cans, and consists of a penetrant, and developer in one set.



(3) Pretreat the inspection surface with the cleaner. Spray the cleaner directly onto the inspection surface, or wipe the inspection surface with a cloth moistened with the cleaner.
(4) Spray the red penetration liquid onto the inspection surface. After cleaning the inspection surface, spray the red penetrant (dye penetration flaw detection agent) onto it and allow the liquid to penetrate for 5-10 minutes.
If the penetrant fails to penetrate the inspection surface because of the ambient temperature or other conditions, allow it to dry and respray the inspection surface.
(5) Spray the developer onto the inspection surface. After penetration processing, remove the residual penetrant from the inspection surface with the cleaner, and then spray the developer onto the inspection surface. If the inspection surface is flawed, red dots or lines will appear on the surface within several minutes. When spraying the developer onto the inspection surface, hold the can about 30—40cm from the surface and sweep the can slowly back and forth to obtain a uniform film.
(6) Reclean the inspection surface with the cleaner.

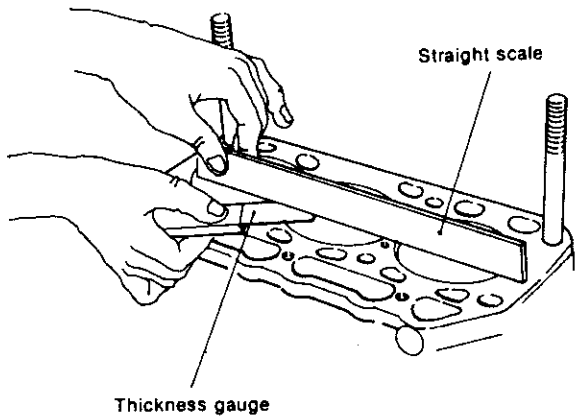
NOTE: Before using the dye penetration flaw detection agent, read its usage instructions thoroughly.

1-3 Measurement of distortion on the upper surface of the cylinder

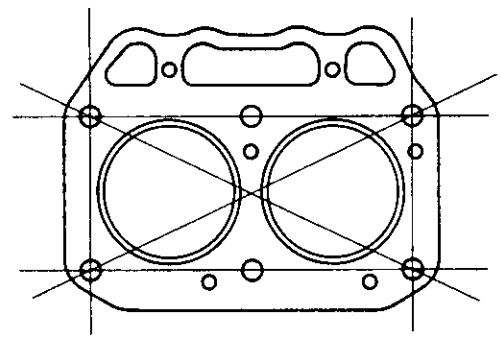
As the cylinder is subjected to thermal expansion and high pressure repeatedly, it will not recover its original shape after the engine has stopped and cooled down and will be distorted. The distortion is mainly caused by construction and material differences of the cylinder, but may arise from the cylinder head bolts being tightened in the wrong order or an uneven tightening torque of the bolts when assembling. If there is any distortion at the upper surface of the cylinder, it will cause a compression pressure leakage, gas leakage or water leakage as a clearance is formed around the cylinder head even though the cylinder head is thoroughly secured.

(1) How to measure distortion on the upper surface of the cylinder

The amount of distortion is measured by placing a straight scale on the upper surface of the cylinder and inserting a thickness gauge between the upper surface of the cylinder and the straight scale.



Measurement is to be carried out on the 4 sides and 2 diagonal lines as shown in the figure, and the largest value of clearance for each measurement is to be taken as the amount of distortion.



mm (in.)

	Allowable limit of distortion
2GMFY	0.07 (0.0028)
3GMFY	0.07 (0.0028)

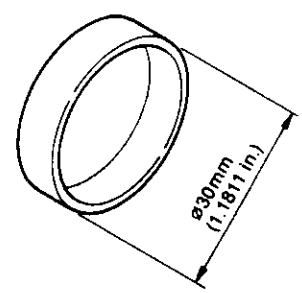
1-4 Cup plug

1-4.1 Purpose of cup plug

In order to minimize the danger of cylinder block breakage caused by the cooling water freezing, a cup plug is provided at the side of the cylinder block to prevent damage by frost.

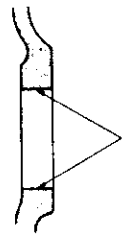
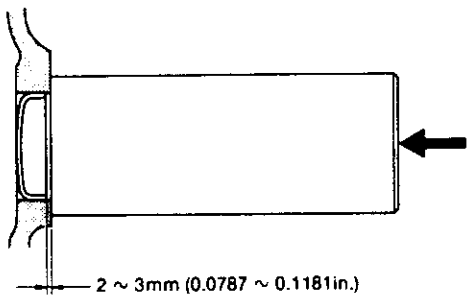
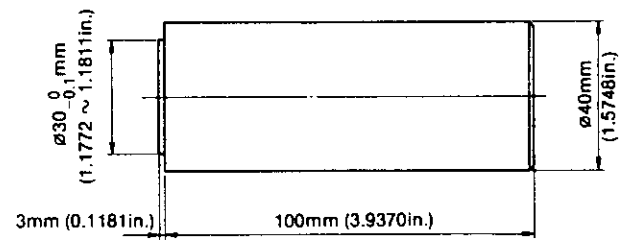
In the event that freezing cooling water has caused the cup plug to come out repair in the following way.

In cold weather it is necessary to drain the cooling water completely from the inside of the cylinder block through the cooling water drain pipe.



	2GMFY	3GMFY
No. of plugs used	4	5
Part No.	105311-01090	

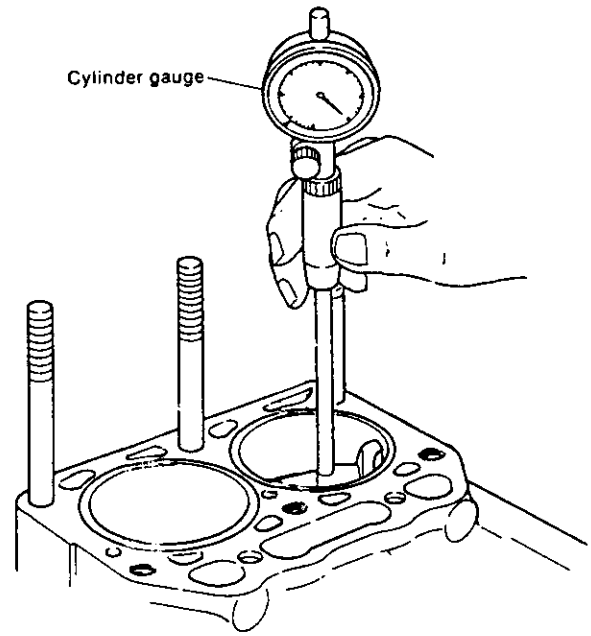
1-4.2 How to drive in the cup plug

Step No.	Description	Procedure	Tool or material used
1.	Clean and remove grease from the hole into which the cup plug is to be driven. (Remove scale and sealing material previously applied.)	 Remove foreign materials with screw driver or saw blade.	•Screw driver or saw blade •Thinner
2.	Remove grease from the cup plug.	Visually check the nick around the plug.	•Thinner
3.	Apply Threebond No. 4 to the seat surface where the plug is to be driven in.	Apply over the whole outside of the plug.	•Threebond No. 4
4.	Insert the plug into the hole.	Insert the plug so that it seats correctly.	
5.	Place a driving tool on the cup plug and drive it in using a hammer.  2 ~ 3mm (0.0787 ~ 0.1181in.) *Using the special tool drive the cup plug to a depth where the edge of the plug is 2mm (0.0787in.) below the cylinder surface.	Drive in the plug parallel to the seating surface.  ø30 $^{0}_{-0.1}$mm (1.1772 ~ 1.1811in.) ø40mm (1.5748in.) 3mm (0.1181in.) 100mm (3.9370in.)	•Driving tool •Hammer

2. Cylinder Liner

2-1 Construction

The cylinder liner is the thin wall type of liner (thickness 2mm [0.0787in.]) made of special cast-iron which is highly wear resistant, and its inside surface is finished by honing. (It has non chrome-plated inside.)
The part of the liner fitting against the cylinder is ground to a precise finished, and clearance between the liner and cylinder is greater towards the top of the cylinder in order to prevent any abnormal deformation which will occur with thermal expansion.
Clearance is always kept to within 10μ to 30μ when assembling by selecting the appropriate liner, from the 3 kinds with different dimensions, by measurng the inside diameter of the cylinder and the outside diameter of the liner.

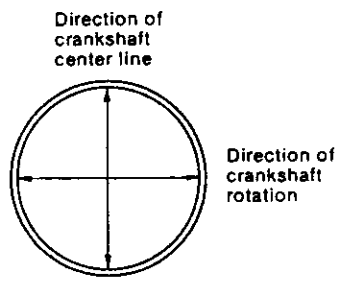


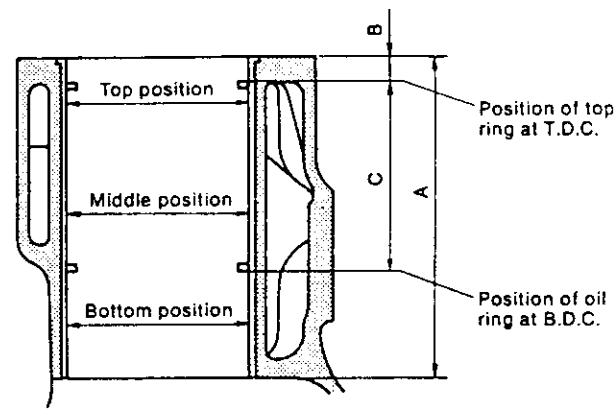
2-2 Inspection

Since the piston and piston rings constantly slide against the cylinder liner while the engine is in operation, and side pressure is applied to the cylinder liner by the movement of the crankshaft, eccentric wear occurs easily.
Moreover, if lubrication and cooling are insufficient, the inner surface will be damaged or rusted. Inspect the inner surface and replace the cylinder liner if the surface is noticeably damaged or rusted.

2-3 Cylinder liner bore diameter measurement

Measure the bore diameter of the cylinder liner with a cylinder gauge at the positions shown in the figure. Replace the cylinder liner when the measured value exceeds the wear limit.
Measurements are to be taken in at least 3 positions as shown in the figure, namely, top, middle and bottom positions in both directions of crankshaft rotation and crankshaft center line.





mm (in.)

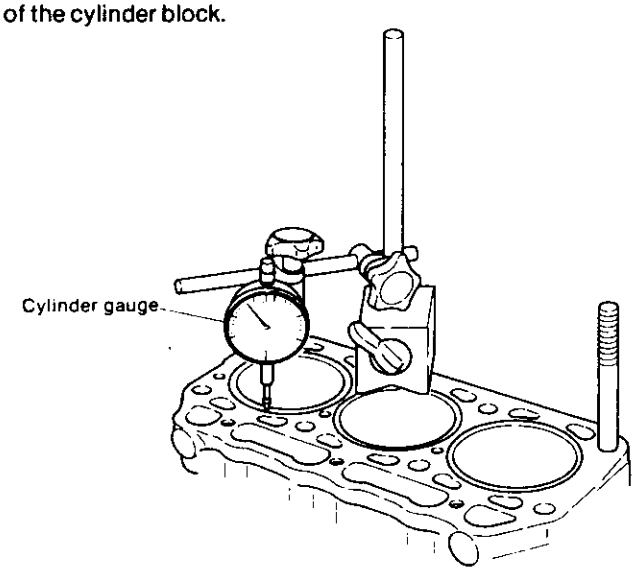
	A	B	C
2GMFY,3GMFY	125 (4.9213)	10.5 (0.4134)	85 (3.3465)

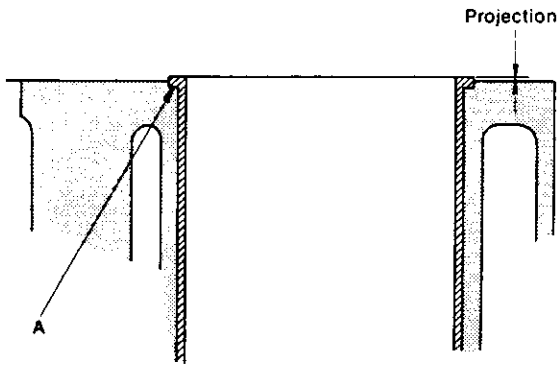
mm (in.)

		Maintenance standard	Clearance at assembly	Wear limit
2GMFY,3GMFY	Cylinder liner diameter	ø72 (2.8346)	0.057 ~ 0.117 (0.0022 ~ 0.0046)	ø72.10 (2.8386)
	Piston outside diameter	ø72 (2.8346)		ø71.85 (2.8287)
	Cylinder liner roundness	0.02 (0.0008)	—	0.04 (0.0016)

2-4 Measuring cylinder liner projection

The flange of the cylinder liner projects slightly from the end surface of the cylinder. This projection will bed into the gasket packing so as to prevent compression pressure leakage or gas leakage. However, if the projection is excessive, compression pressure or gas leakage may occur because the gasket packing is damaged. On the otherhand, if the projection is insufficient, the cylinder liner can not be securely fixed.
Excessive cylinder liner projection is frequently caused by incomplete removal of the rust at the ledge (part A of figure) of the cylinder block.





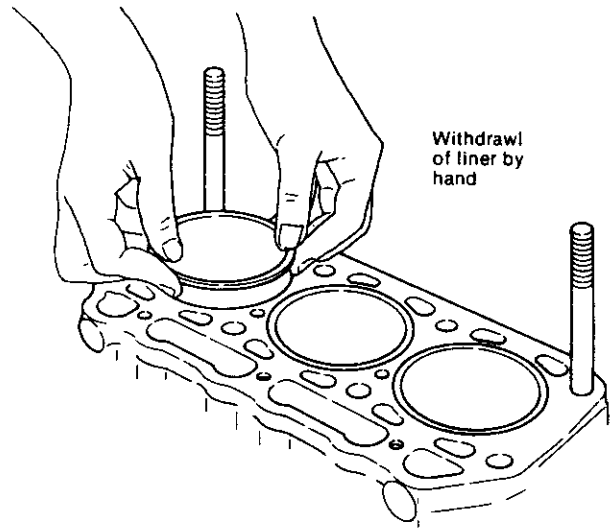
mm (in.)

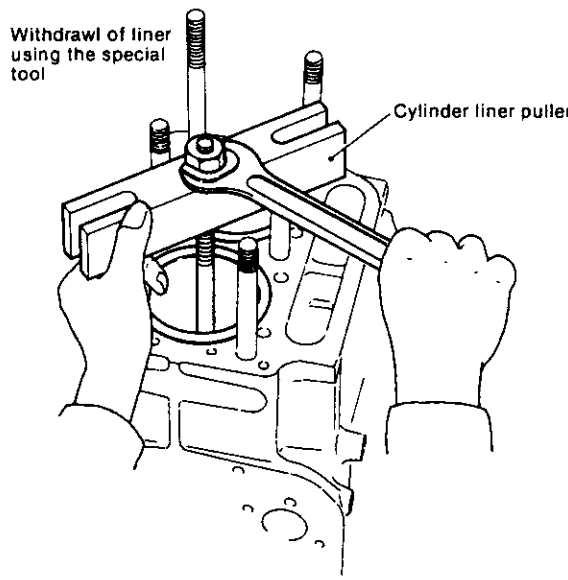
Cylinder liner projection	0.005 ~ 0.075 (0.0002 ~ 0.0030)

2-5 Cylinder liner replacement

2-5.1 Withdrawl of cylinder liner

As the liner used in these engines is especially fitted to the cylinder to ensure constant clearance when assembled, it fits closely to the cylinder while running to enable good heat conduction, and can be easily withdrawn when the engine is cool. However, it may prove difficult to withdraw the liner when there is reduced clearance due to cylinder distortion. In such an event, a special tool must be used to withdraw the liner.





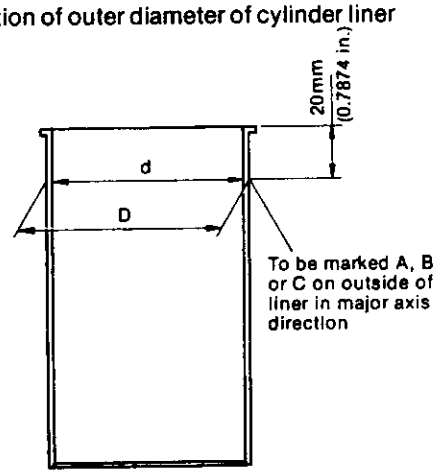
2-5.2 Inserting the cylinder liner

Insert the liner by hand after applying oil to the whole of the outside of the liner.
(Tapping with a wooden hammer or something may distort it.)

2-5.3 Notes on replacing cylinder liner

During assembly at the manufacturing plant, the inner diameter of the cylinder and the outer diameter of the liner are measured and classified into three categories so that they can be matched and fitted. For replacement parts (service part), the liner with dimensions listed in Notation B in the following table is to be used.

(1) Classification of outer diameter of cylinder liner



mm (in.)

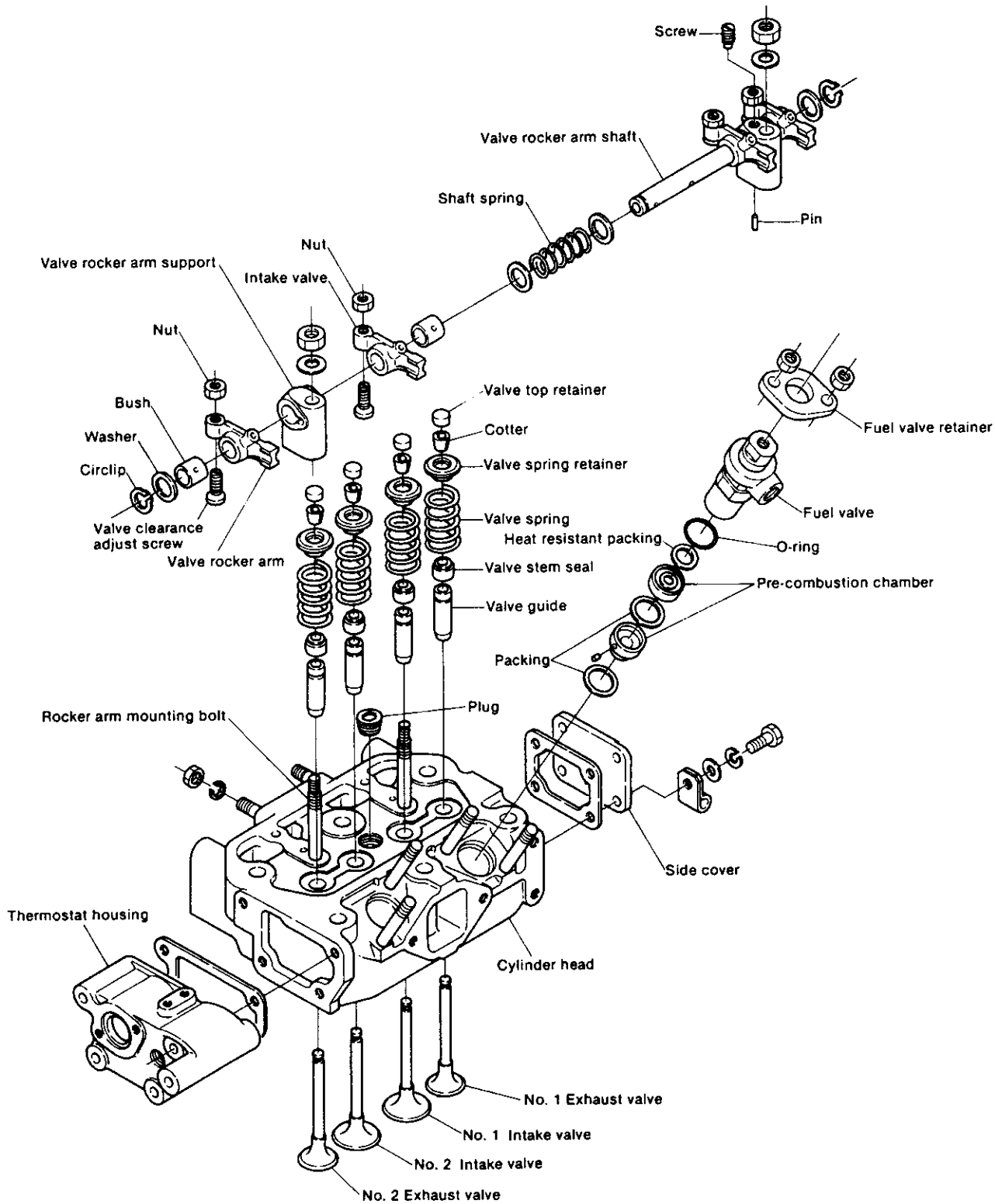
Notation	Dimension D
A	$76^{+0.010}_{0}$ (2.9921 ~ 2.9925)
B	$76^{0}_{-0.010}$ (2.9917 ~ 2.9921)
C	$76^{-0.010}_{-0.020}$ (2.9913 ~ 2.9917)

3. Cylinder Head

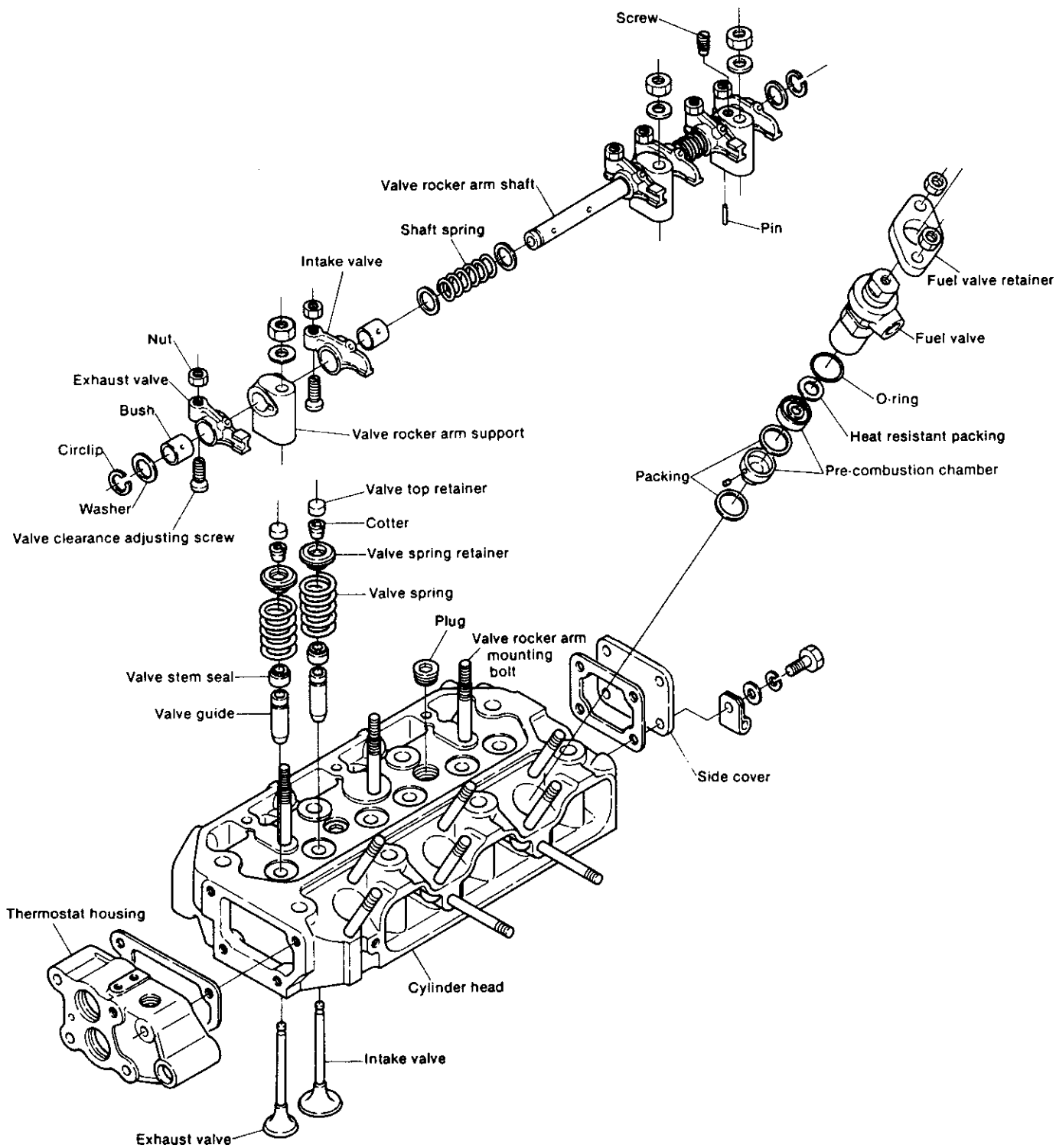
3-1 Construction

The cylinder head is an integral two/three cylinder type which is bolted to the block.
The unique Yanmar swirl type precombustion chambers are at an angle in the cylinder head, and form the combustion chambers, together with the intake and exhaust valves. Large diameter intake valves and smoothly shaped intake and exhaust ports provide high intake efficiency and superior combustion performance.
Special consideration has also been given to the shape of the cooling water passages so that the combustion surface and precombustion chamber are uniformly cooled by an ample water flow.
The thermostat is installed on the side surface of the cylinder at the timing gear case side. (On models 2GMFY, 3GMFY, it is integrated with the alternator bracket).

3-1.1 Cylinder head of model 2GMFY engine



3-1.2 Cylinder head of models 3GMFY



3-2 Cylinder head inspection and measurement

3-2.1 Measurement of carbon build-up at combustion surface and intake and exhaust ports

Visually check for carbon build-up around the combustion surface and the port near the intake and exhaust valve seats, and remove any build-up.
When a large amount of carbon has built up, check the top of the chamber combustion for oil flow at the intake and exhaust valve guides, and take suitable corrective action.

3-2.2 Deposit build-up in water passages

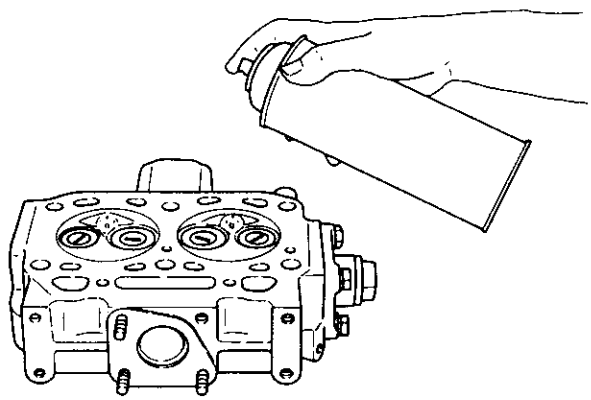
Check for build-up deposit in the water passages, and remove any deposit with a deposit remover. When a large amount of deposit has built up, check each part of the cooling system.

3-2.3 Inspection of corrosion in water passages and anti-corrosion zinc

Inspect the state of corrosion of the water passages, and replace the cylinder head when corrosion is severe.
Corrosion pitting limit: 2mm (0.0787in.)
Inspect the anticorrosion zinc on the cylinder head cover, and replace the zinc when it has worn over the wear limit.
Anticorrosion zinc wear limit: Volumetric ratio with new zinc = 1/2

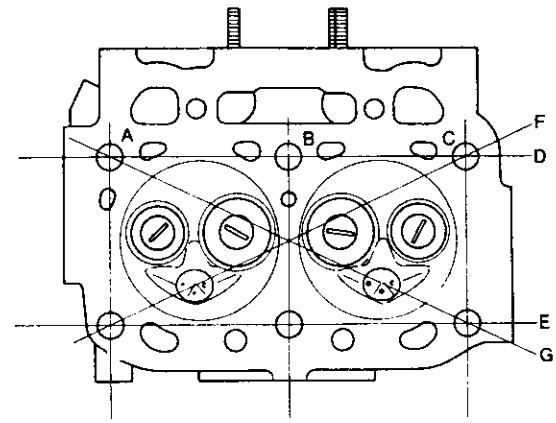
3-2.4 Cracking of combustion surface

The combustion surface is exposed to high temperature, high pressure gas and low temperature air, and is repeatedly flexed during operation. Moreover, it is used under extremely severe conditions, such as the high temperature difference between the combustion surface and cooling water passages.
Inspect the combustion surface for cracking by the color check, and replace the cylinder head if any cracking is detected. At the same time, check for signs of overloading and check the cooling water flow.



3-2.5 Cylinder head distortion

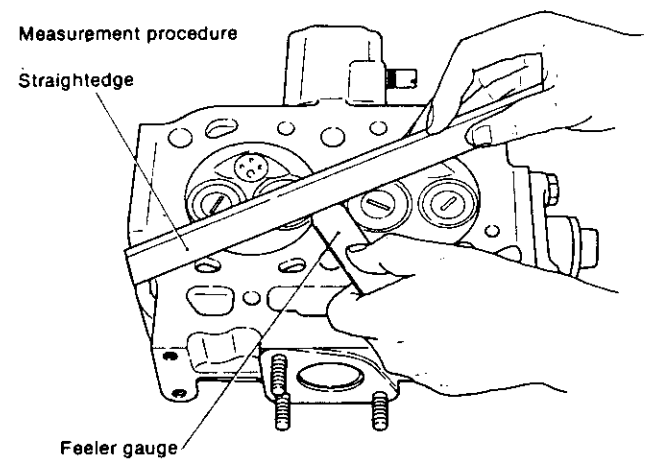
Distortion of the cylinder head causes gasket packing damage, compression leakage, change in compression, etc.
Measure the distortion as described below, and replace the cylinder head when the wear limit is exceeded. Since distortion of the cylinder head is caused by irregular tightening forces, faulty repair of the mounting face, and gasket packing damage, these must also be checked.



Cylinder head distortion mm (in.)

	Wear limit
2GMFY	0.07 (0.0028)
3GMFY	0.07 (0.0028)

(1) Clean the cylinder head tightening surface.
(2) Place a straightedge across two symmetrical points at the four sides of the cylinder head, as shown in the figure.
(3) Insert feeler gauges between the straightedge and the cylinder head combustion face.

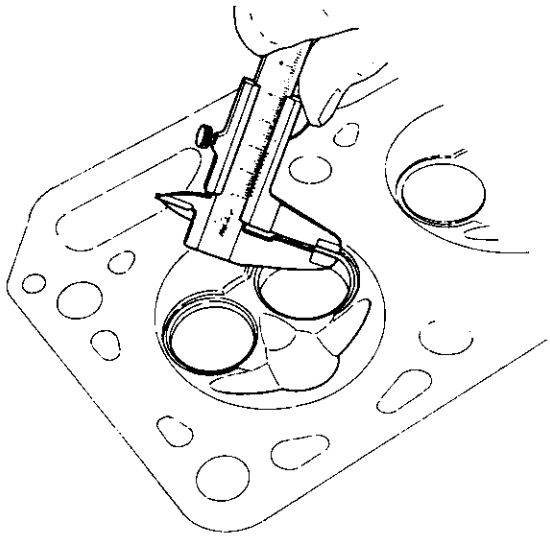


(4) The thickness of the largest feeler gauge that can be inserted is the amount of distortion.

3-2.6 Cylinder head valve seat

The valve seats become wider with use. If the seats become wider than the maintenance standard, carbon built-up at the seats will cause compression leakage. On the other hand, if the seats are too narrow, they will wear quickly and heat transmission efficiency will deteriorate. Clean the carbon and other foreign matter from the valve seats, and check that the seats are not scored or dented.

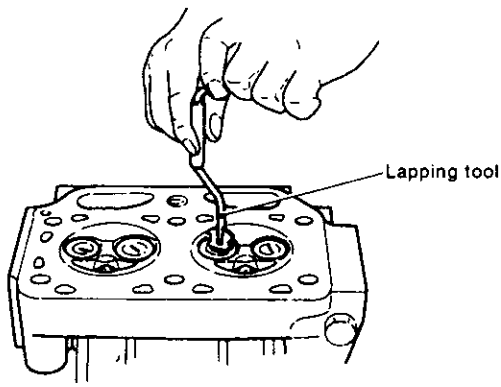
Measure the seat width with vernier calipers, and repair or replace the seat when the wear limit is exceeded.
When the valves have been lapped and/or ground, measure the amount of valve recess, and replace the valve when the wear limit is exceeded.



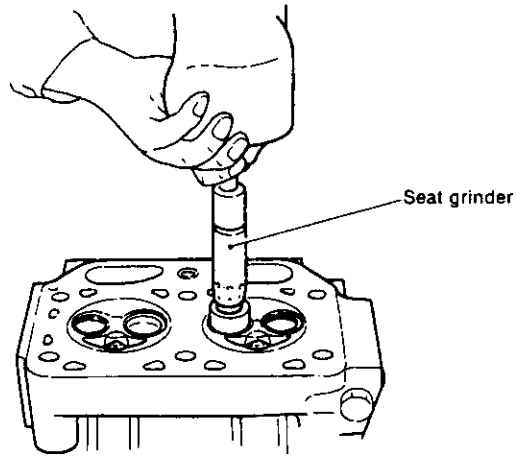
(Common to 4 models) mm (in.)

	Maintenance standard	Wear limit
Seat width	1.77 (0.06969)	—
Seat angle	90°	—

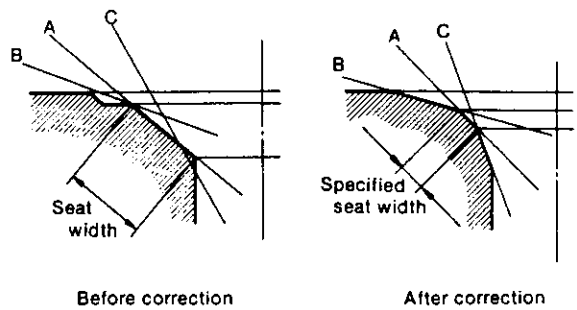
(1) Lapping the valve seat.
When scoring and pitting of the valve seat is slight, coat the seat with valve compound mixed oil, and lap the seat with a lapping tool.
At this time, be sure that the compound does not flow into the valve stem and valve guide.



(2) Correcting valve seat width.
When the valve seat is heavily pitted and when the seat width must be corrected, repair with a seat grinder.
1) Repair pitting of the seat face with a 45° grinder.
2) Since the valve seat is larger than the initial value, correct the seat width to the maintenance standard by grinding the inside face of the seat with a 70° grinder.
3) Grind the outside face of the valve seat with a 15° grinder, and finish the seat width to the standard value.



4) Mix the compound with oil, and lap the valve.
5) Finally, lap with oil.



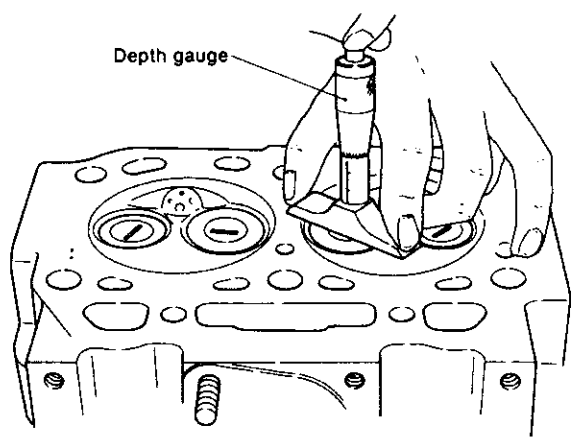
Before correction After correction

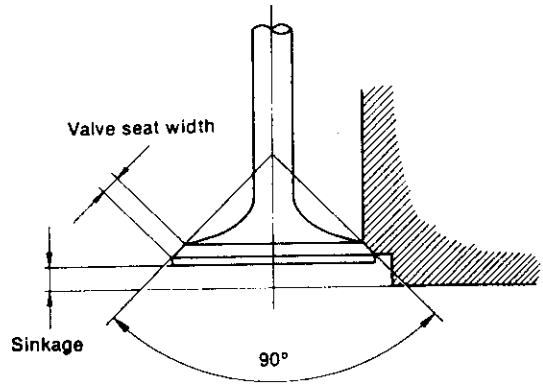
(A) Grind with a 45° grinder
(B) Grind with a 15° grinder
(C) Grind with a 65° ~ 75° grinder

NOTE: When the valve seat has been corrected with a seat grinder, insert an adjusting shim between the valve spring and cylinder head.

3-2.7 Measuring valve sinkage

When the valve has been lapped many times, the valve will be recessed and will adversely affect combustion performance. Therefore, measure the valve sinkage, and replace the valve and cylinder head when the wear limit is exceeded.





mm (in.)

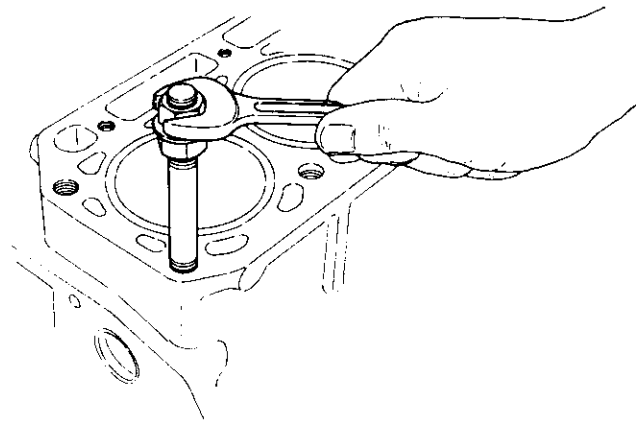
	2GMFY, 3GMFY	
	Maintenance standard	Wear limit
Valve sinkage	0.95 (0.0374)	1.25 (0.0492)

3-2.8 Rocker arm support positioning pin (for model 1GM)

Check if the guide pin is damaged or if the hole is clogged, and replace the pin if faulty.

3-3 Dismounting and remounting the cylinder head

When dismounting and remounting the cylinder head, the mounting bolts must be removed and installed gradually and in the prescribed sequence to prevent damaging the gasket packing and to prevent distortion of the cylinder head. Since the tightening torque and tightening sequence of the mounting bolts when remounting the cylinder head are especially important from the standpoint of engine performance, the following items must be strictly observed.



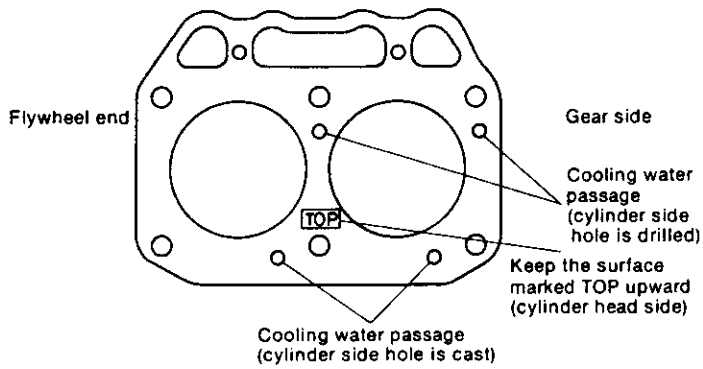
3-3.1 Cylinder head assembly sequence

(1) Check for loose cylinder head stud bolts, and lock any loose bolts with two nuts and then tighten to the prescribed torque.
The cylinder head is fitted to the engine with 4 stud bolts in model 1GM, but in other engine models both stud bolts and auxiliary tap bolts are used.

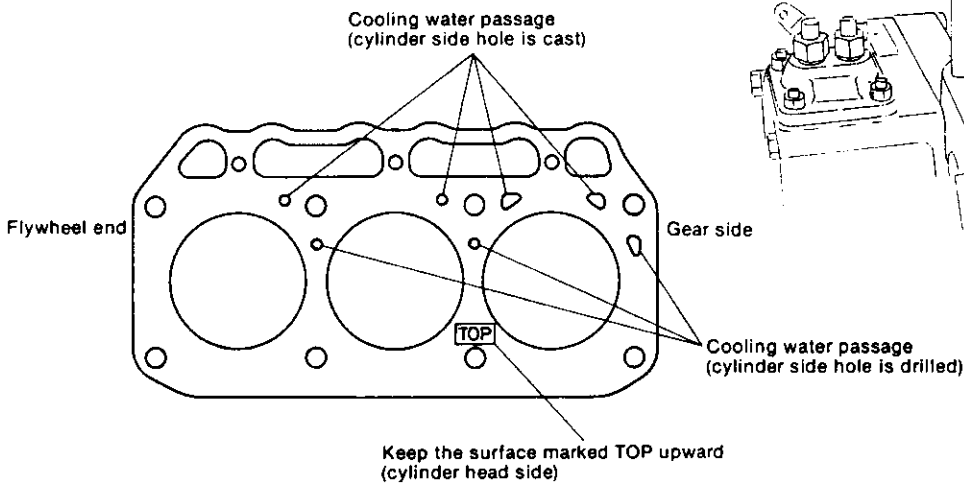
	2GMFY, 3GMFY
Stud bolt diameter of cylinder head	M12 (0.4724in.)
Cylinder head stud bolt tightening torque	4.0 ~ 4.5 kgf-m (28.9 ~ 32.5 ft-lb)

(2) Checking the gasket packing mounting face.
Confirm correct alignment of the front and rear of the gasket packing, and install the packing by coating both sides with Three Bond 50.
Assemble the gasket packing keeping the flat surface upward (cylinder head side). Make sure that the gasket hole aligns with the drilled hole in the cooling water passage in the cylinder block.

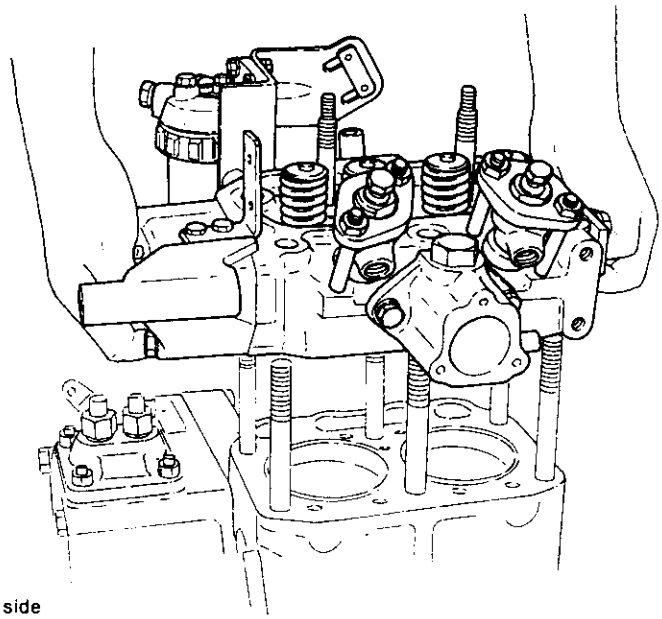
1) For model 2GMFY


Flywheel end
Gear side
Cooling water passage (cylinder side hole is drilled)
TOP
Keep the surface marked TOP upward (cylinder head side)
Cooling water passage (cylinder side hole is cast)

2) For models 3GMFY


Cooling water passage (cylinder side hole is cast)
Flywheel end
Gear side
TOP
Cooling water passage (cylinder side hole is drilled)
Keep the surface marked TOP upward (cylinder head side)

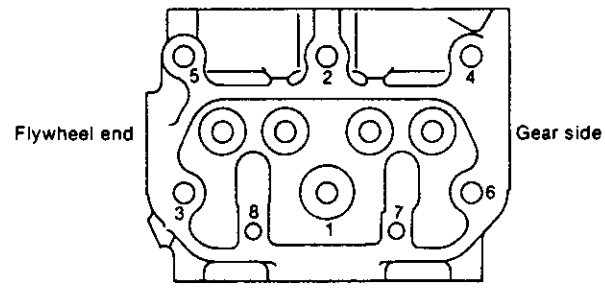
(3) Installing the cylinder head ass'y.
Position the cylinder head ass'y parallel to the top of the cylinder block, and install the ass'y on the block, being careful that the cylinder head ass'y does not touch the threads of the cylinder head bolts.



3-3.2 Tightening the cylinder head bolts and nuts

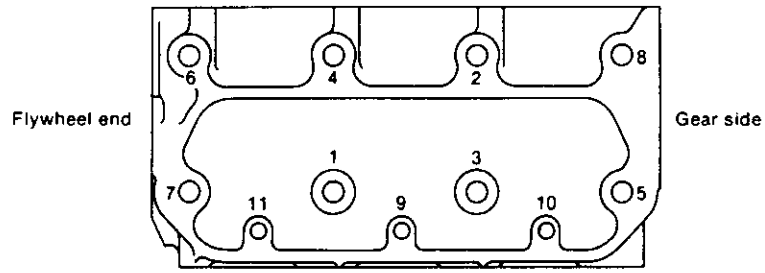
(1) Kinds of cylinder head fixing nuts and bolts, tightening torpue, tihteining sequence

1) Model 2GMFY



Tightening sequence	Kinds of fixing	Dia.	Tightening Torque
1, 2, 3, 4, 5, 6	Stud bolt fixing nut	M12 (0.4724in.)	10 kgf-m (72.3 ft-lb)
7, 8	Auxiliary tap bolt	M8 (0.3150in.)	2.5 kgf-m (18.1 ft-lb)

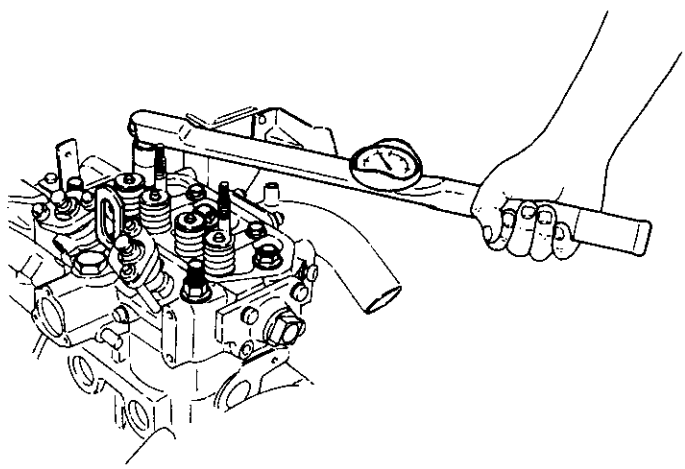
2) Models 3GMFY



Tightening sequence	Kinds of fixing	Dia.	Tightening torque
1, 2, 3, 4, 5, 6, 7, 8	Stud bolt fixing nut	M12 (0.4724in.)	10 kgf-m (72.3 ft-lb)
9, 10, 11	Auxiliary tap bolt	M8 (0.3150in.)	2.5 kgf-m (18.1 ft-lb)

(2) Cylinder head nut tightening sequence

1) Coat the threads of the cylinder head bolts with lubricating oil, and screw the cylinder head nuts onto the bolts.



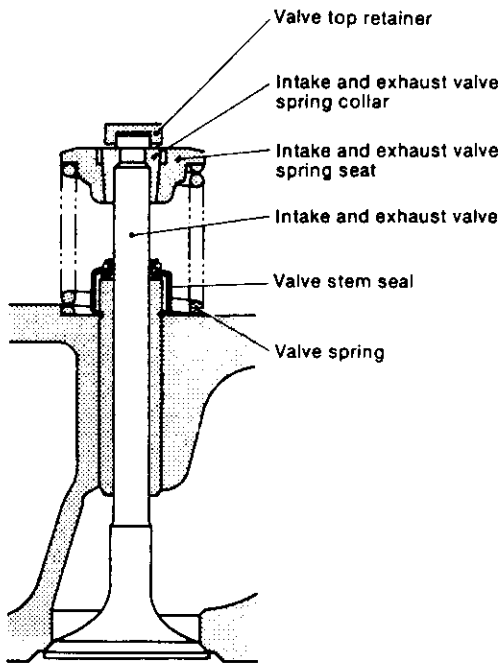
2) First, tighten the nuts sequentially to 1/3 of the prescribed torque.
3) Second, tighten the nuts sequentially to 2/3 of the prescribed torque.
4) Third, tighten the nuts to the prescribed torque.
5) Recheck that all the nuts have been properly tightened.

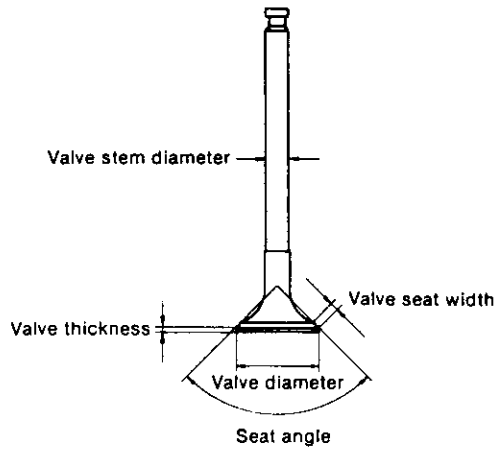
NOTE: After tightening, valve clearance must be adjusted.

3-3.3 Cylinder head nut loosening sequence

When loosening the cylinder head nuts, reverse the tightening sequence. The cylinder head nut loosening sequence is shown in the figure.

3-4 Intake and exhaust valves, valve guide and valve spring


Valve top retainer
Intake and exhaust valve spring collar
Intake and exhaust valve spring seat
Intake and exhaust valve
Valve stem seal
Valve spring



mm (in.)

Intake valve diameter	ø32 (1.2598)
Exhaust valve diameter	ø26 (1.0236)
Valve seat width	3.15 (0.1240)
Valve seat angle	90°

NOTE: Note that the intake valve and exhaust valve have a different diameter.

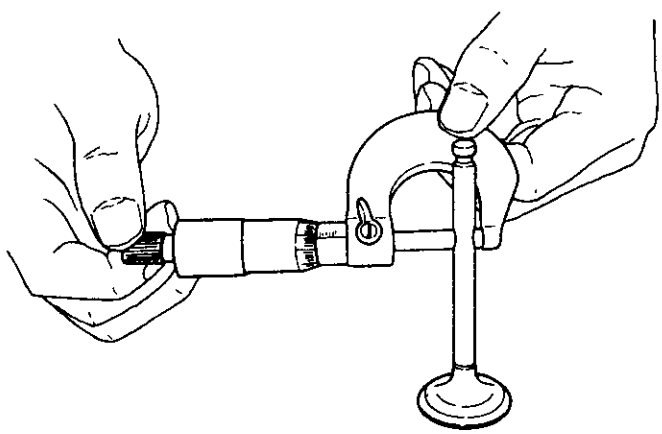
3-4.1 Inspecting and measuring the intake and exhaust valves

(1) Valve seat wear and contact width.
Inspect valve seats for carbon build-up and heavy wear. Also check if each valve seat contact width is suitable. If the valve seat contact width is narrower than the valve seat width, the seat angle must be checked and corrected.

mm (in.)

	Maintenance standard	Wear limit
Valve thickness	0.75 ~ 1.15 (0.0295 ~ 0.0453)	—

(2) Valve stem bending and wear.
Check for valve stem wear and strain, and repair when such damage is light. Measure the outside diameter and bend, and replace the valve when the wear limit is exceeded.



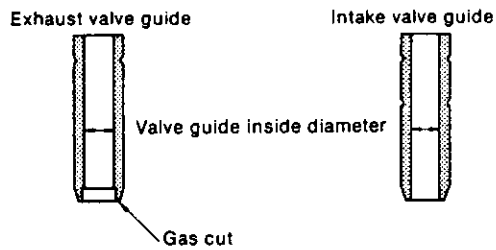
mm (in.)

	Maintenance standard	Wear limit
Valve stem outside diameter	ø7 (0.2756)	ø6.9 (0.2717)
Valve stem bend	—	0.03 (0.0012)

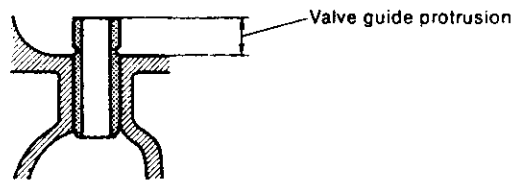
(3) Valve seat hairline cracks.
Inspect the valve seat by the color check, and replace the seat if cracked.

3-4.2 Inspecting and measuring valve guides

The same valve guide is used both for intake and exhaust valves in the model 1GM engine. It has a gas blow opening cut in the inner face at the bottom.
The valve guide is different for the intake valve and exhaust valve in that the inner face of the exhaust valve guide has a gas blow opening cut.
Be sure that the correct one is used when replacing the guides.



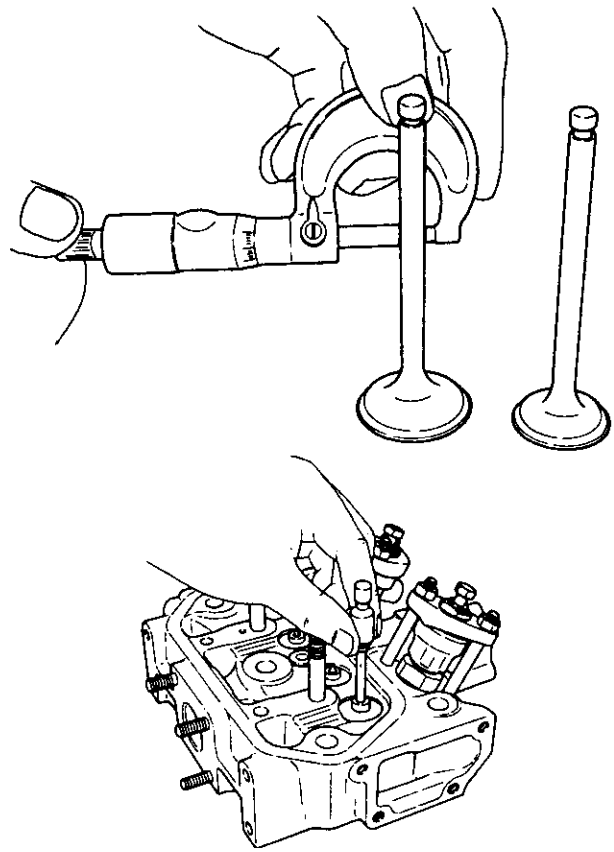
(1) Floating of the intake and exhaust valve guides.
Check for intake and exhaust valve guide looseness and floating with a test hammer, and replace loose or floating guides with guides having an oversize outside diameter.



mm (in.)

Valve guide protrusion	7 (0.2756)

(2) Measuring the valve guide inside diameter.
Measure the valve guide inside diameter and clearance, and replace the guide when wear exceeds the wear limit.

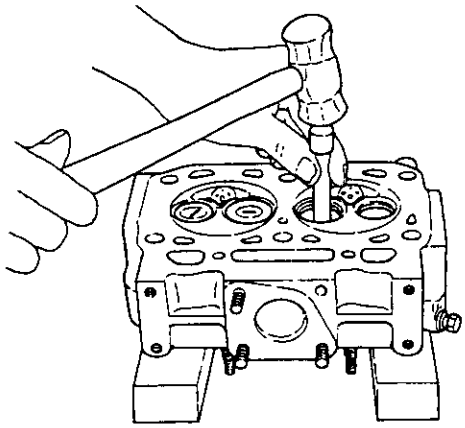


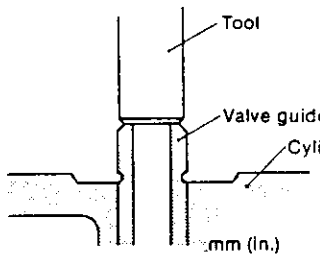
mm (in.)

		Maintenance standard	Clearance at assembly	Maximum allowable clearance	Wear limit
Intake	Valve guide inside diameter (after assembly)	ø7 (0.2756)	0.040 ~ 0.065 (0.0016 ~ 0.0026)	0.15 (0.0059)	ø7.08 (0.2787)
	Stem outside diameter	ø7 (0.2756)			ø6.9 (0.2717)
Exhaust	Valve guide inside diameter (after assembly)	ø7 (0.2756)	0.045 ~ 0.070 (0.0018 ~ 0.0028)	0.15 (0.0059)	ø7.08 (0.2787)
	Stem outside diameter	ø7 (0.2756)			ø6.9 (0.2717)

(3) Replacing the intake/exhaust valve guide

1) Using a special tool for extracting and inserting the valve guide, extract the valve guide.

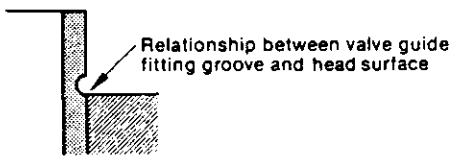




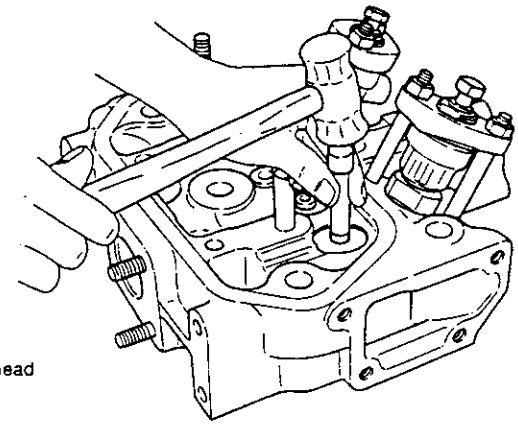
mm (in.)

	2GMFY, 3GMFY
Amount of interference of valve guide	0.018 ~ 0.047 (0.0007 ~ 0.0019)

Fit the intake and exhaust valve guides until the bottom of the groove around the outside of the valve guide is flush with the end of the cylinder head.



2) Using the above tool, drive the valve guide into position by starting from the valve spring side and finish the inside diameter with a reamer.



3-4.3 Valve spring

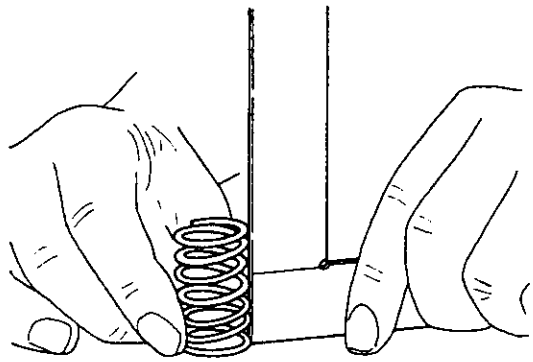
(1) Valve spring inclination.

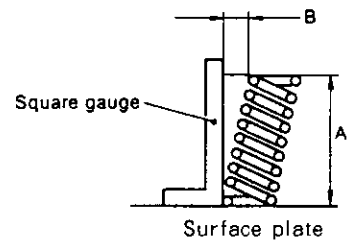
Since inclination of the valve spring is a direct cause of eccentric contact of the valve stem, always check it at disassembly.

Stand the valve upright on a stool, and check if the entire spring contacts the gauge when a square gauge is placed against the outside diameter of the valve spring.

If there is a gap between the gauge and spring, measure the gap with a feeler gauge.

When the valve spring inclination exceeds the wear limit, replace the spring.





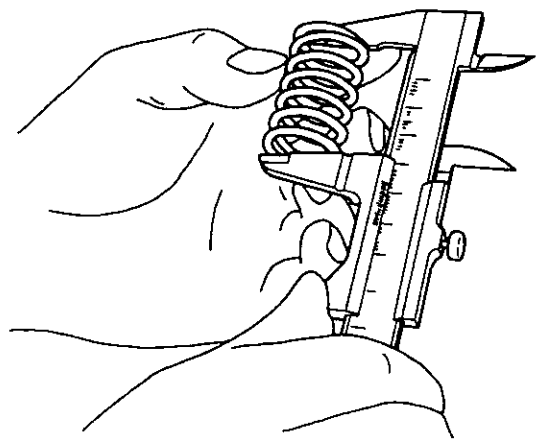
mm (in.)

	Maintenance standard
Valve spring free length (A)	38.5 (1.5157)

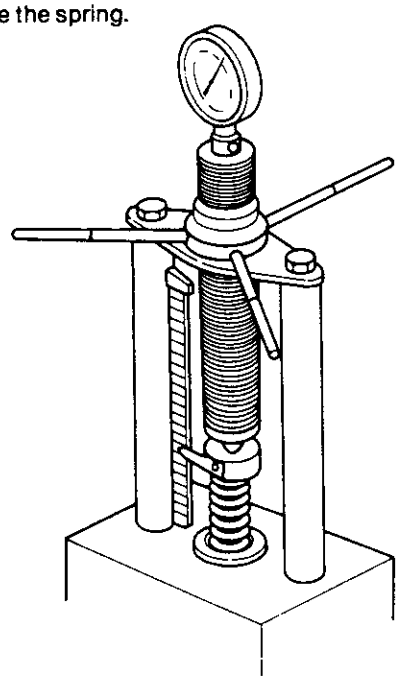
Allowable tilt value (B/A) is less than 0.035

(2) Valve spring free length.

Measure the free length of the valve spring, and replace the spring when the wear limit is exceeded.

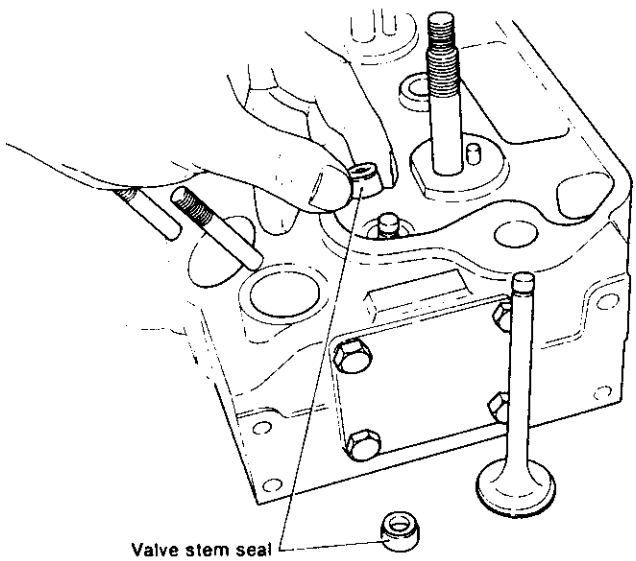


Also, measure the tension of the spring with a spring tester. If the tension is below the prescribed limit, replace the spring.

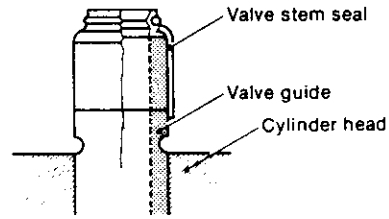


	Maintenance standard	Wear limit
Valve spring free length	38.5mm (1.5157in.)	37mm (1.4567in.)
Length when attached	29.2mm (1.1496in.)	—
Load applied attached	16.16kg (35.63lb)	13.7kg (30.20lb)

3-4.4 Valve stem seal

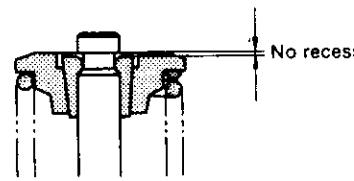


A valve stem seal is assembled at the top of the valve guide and the valve stem chamber oil is sucked into the combustion chamber through the valve guide (oil down) to prevent an increase in oil consumption.
The valve stem seal must always be replaced whenever it has been removed.
When assembling, coat the valve stem with engine oil before inserting.



3-4.5 Spring retainer and spring cotter pin

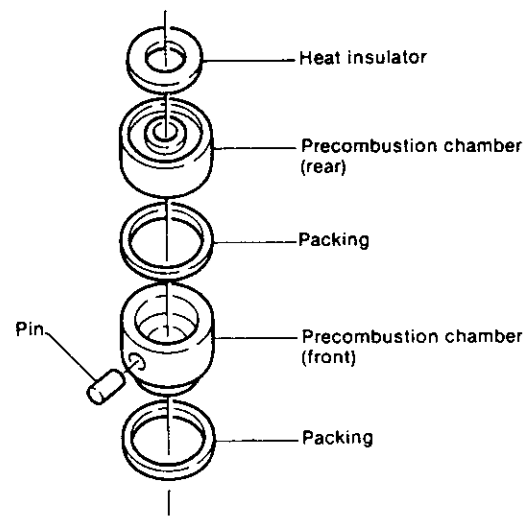
Inspect the inside face of the spring retainer and the outside surface of the spring cotter pin, and the contact area of the spring cotter pin inside surface and the notch in the head of the valve stem. Replace the spring retainer and spring cotter pin when the contact area is less than 70% or when the spring cotter pin has been recessed because of wear.



3-5 Precombustion chamber and top clearance

3-5.1 Precombustion chamber

Remove the packing and insulation packing at the precombustion chamber's front and rear chambers, and inspect. Check for burning at the front end of the precombustion chamber front chamber, acid corrosion at the precombustion chamber rear chamber, and for burned packing. Replace if faulty.

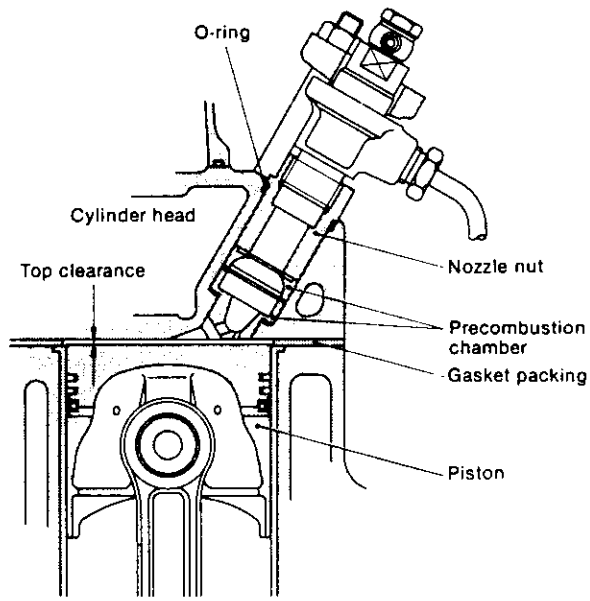


3-5.2 Insulation packing

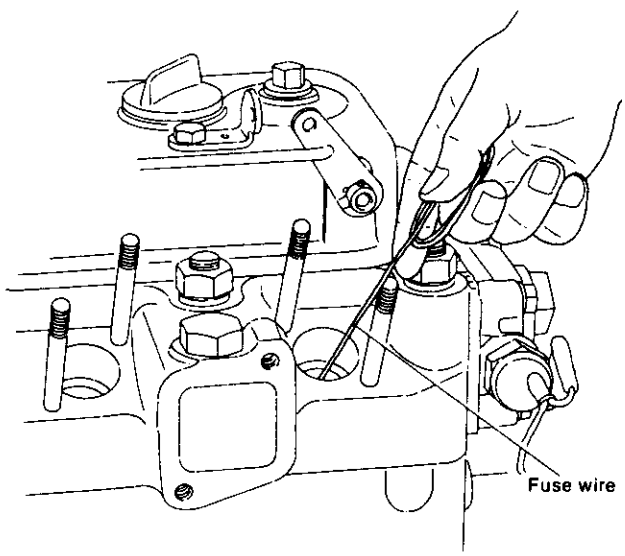
The insulation packing prevents transmission of heat from the precombustion chamber to the nozzle valve and serves to improve the nozzle's durability.
Always put in new insulation packing when it has been disassembled.

3-5.3 Top clearance

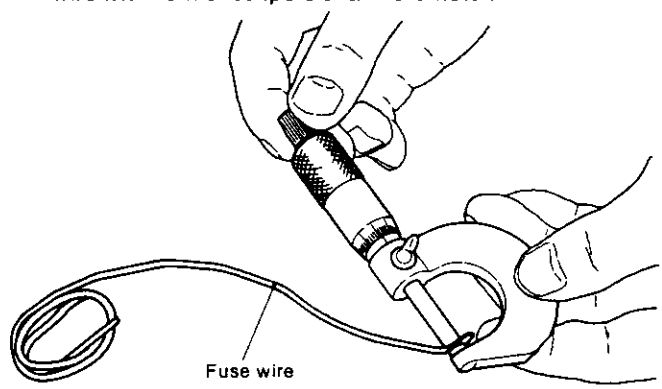
Top clearance is the size of the gap between the cylinder head combustion surface and the top of the piston at top dead center.
Since top clearance has considerable effect on the combustion performance and the starting characteristic of the engine, it must be checked periodically.



(1) Top clearance measurement
1) Check the cylinder head mounting bolts and tightening torque.
2) Remove the fuel injection valve and precombustion chamber.



3) Lower the piston at the side to be measured.
4) Insert quality fuse wire (ø1.2mm, 0.472in.) through the nozzle holder hole. (Be careful that the wire does not enter the intake and exhaust valve and the groove in the combustion surface.)
5) Crush the fuse wire by moving the piston to top dead center by slowly cranking the engine by hand.
6) Lower the piston by hand cranking the engine and remove the crushed fuse wire, being careful not to drop it.
7) Measure the thickness of the crushed part of the fuse wire with vernier calipers or a micrometer.



(2) Top clearance value.

mm (in.)

Top clearance	0.7 (0.0276)

When the top clearance value is not within the above range, check for damaged gasket packing, distortion of the cylinder head combustion surface, or other abnormal conditions.

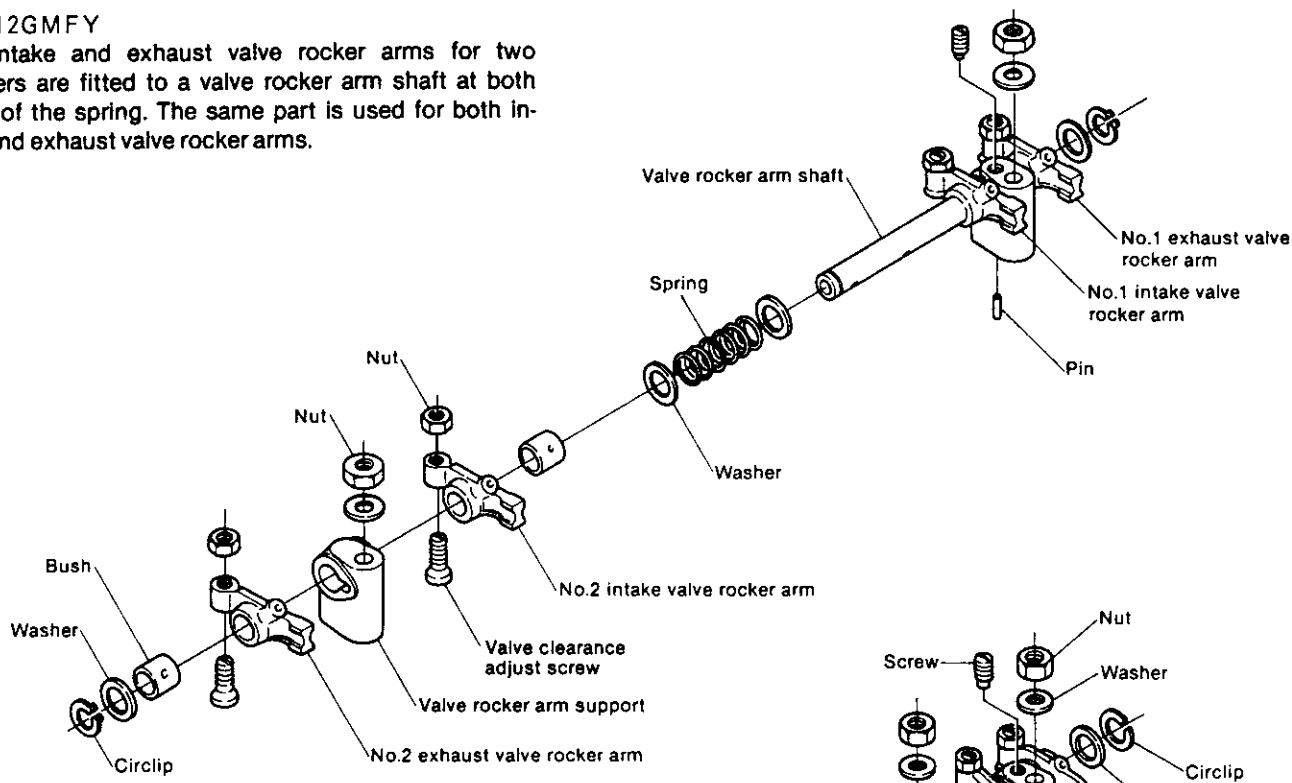
3-6 Intake and exhaust valve rocker arm

Since the intake and exhaust valve rocker arm shaft and bushing clearance and valve head and push rod contact wear are directly related to the valve riming, and have an effect on engine performance, they must be carefully serviced.

3-6. 1 Components of valve rocker arm

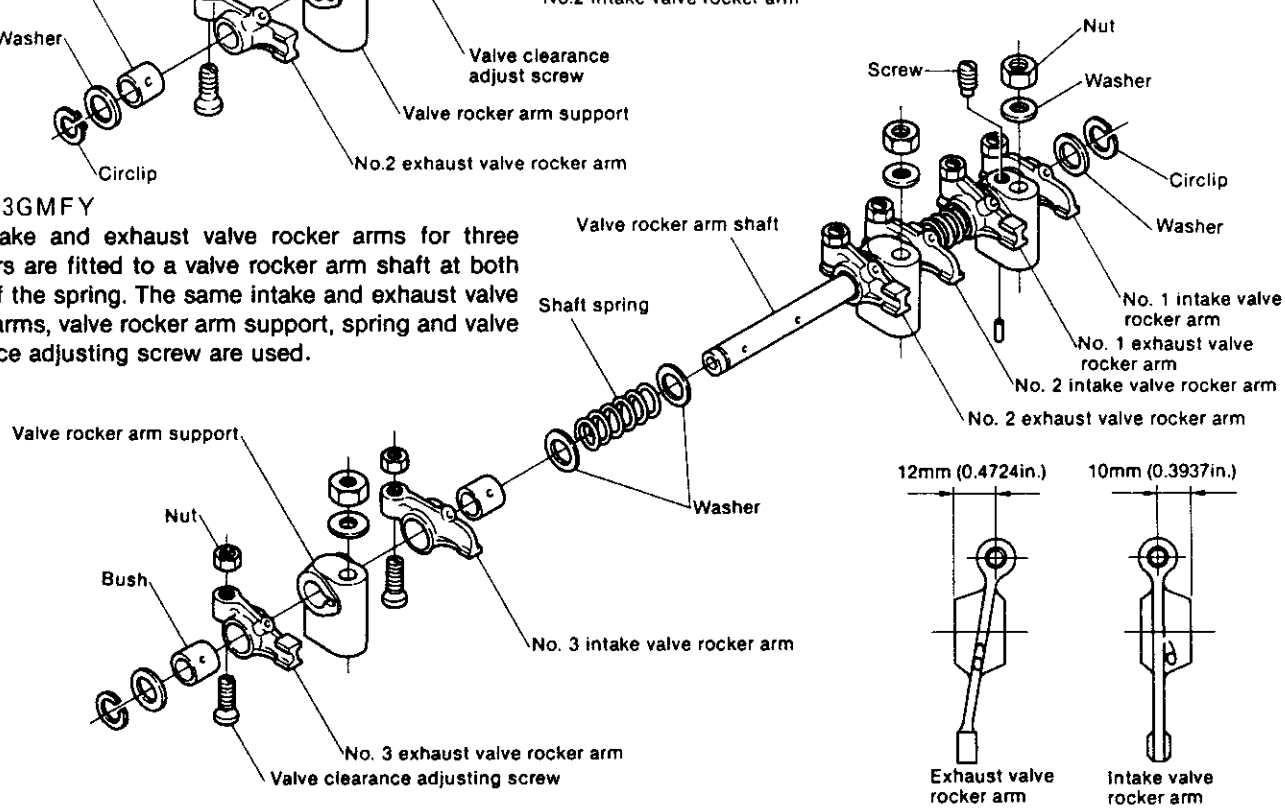
(1) Model 2GMFY

The intake and exhaust valve rocker arms for two cyinders are fitted to a valve rocker arm shaft at both sides of the spring. The same part is used for both intake and exhaust valve rocker arms.



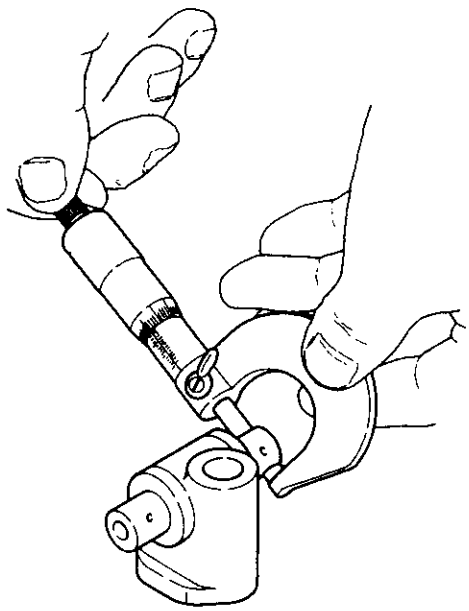
(2) Models 3GMFY

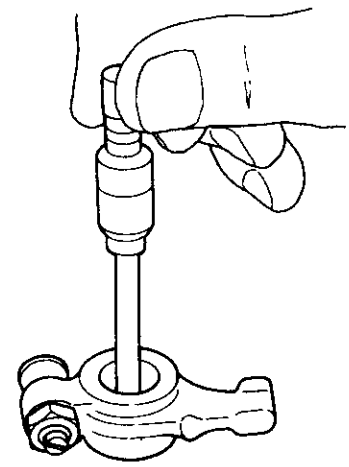
The intake and exhaust valve rocker arms for three cylinders are fitted to a valve rocker arm shaft at both sides of the spring. The same intake and exhaust valve rocker arms, valve rocker arm support, spring and valve clearance adjusting screw are used.

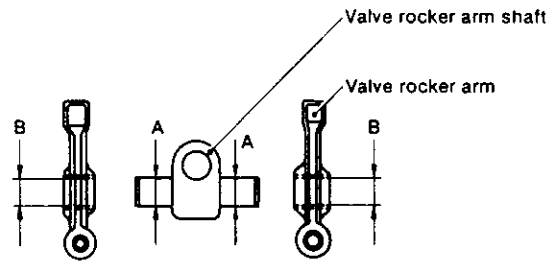


3-6.2 Measuring the valve rocker arm shaft and bushing clearance

Measure the outside diameter of the valve rocker arm shaft and the inside diameter of the bushing, and replace the rocker arm or bushing if the measured value exceeds the wear limit.
Replace a loose valve rocker arm shaft bushing with a new bushing. However, when there is no tightening allowance, replace the valve rocker arm.







mm (in.)

			Maintenance standard	Clearance at assembly	Maximum allowable clearance	Wear limit
2GMFY	Intake and exhaust valve rocker arm shaft outside diameter	A	ø14 (0.5512)	0.016 ~ 0.052 (0.0006 ~ 0.0020)	0.15 (0.0059)	ø13.9 (0.5472)
	Intake and exhaust valve rocker arm bushing inside diameter (assembled)	B	ø14 (0.5512)			ø14.1 (0.5551)
3GMFY	Intake and exhaust valve rocker arm shaft outside diameter	A	ø14 (0.5512)	0.016 ~ 0.052 (0.0006 ~ 0.0020)	0.15 (0.0059)	ø13.9 (0.5472)
	Intake and exhaust valve rocker arm bushing inside diameter (assembled)	B	ø14 (0.5512)			ø14.1 (0.5551)

3-6.3 Valve rocker arm and valve top retainer contact and wear

Check the valve rocker arm and valve top retainer contact, and replace when there is any abnormal wear or peeling.

3-6.4 Valve clearance adjusting screw

Inspect the valve clearance adjusting screw and push rod contact, and replace when there is any abnormal wear or peeling.

3-6.5 Classification of the intake and exhaust valve rocker arms

Since the intake and exhaust valve rocker arms have different shapes, care must be exercised in service and assembly.

3-7 Adjusting intake and exhaust valve head clearance

Adjustment of the intake and exhaust valve head clearance governs the performance of the engine, and must be performed accurately. The intake and exhaust valve head clearance must always be checked and readjusted, as required, when the engine is disassembled and reassembled, and after every 300 hours of operation. Adjust the valve head clearance as described below.

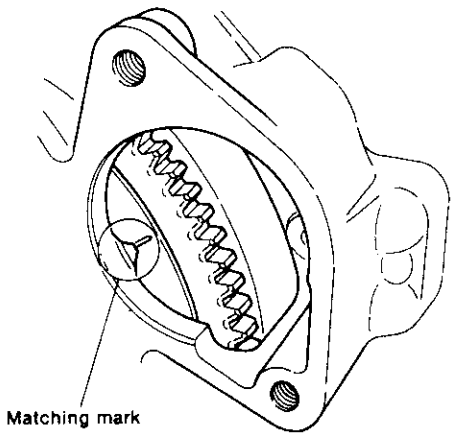
3-7.1 Adjustment

Make this adjustment when the engine is cold.

(1) Remove the valve rocker arm cover.

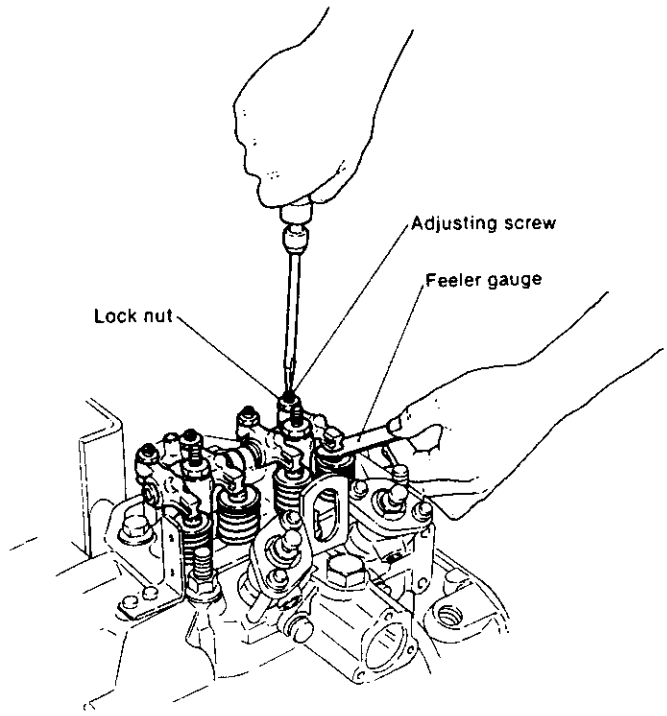
(2) Crank the engine and set the piston to top dead center (TDC) on the compression stroke.

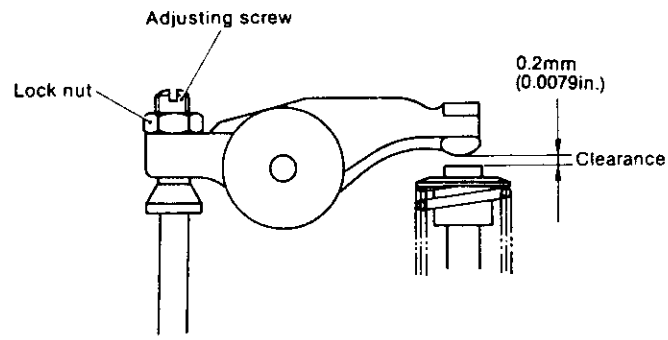
The matching mark is made at the setting hole of the starter motor on all models.



NOTE: Set to the position at which the valve rocker arm shaft does not move even when the crankshaft is turned to the left and right, centered around the matching mark.

(3) Check and adjust the intake and exhaust valve head clearances of the No. 1 piston.
Loosen the valve clearance adjusting screw lock nut, adjust the clearance to the maintenance standard with a feeler gauge, and retighten the lock nut.





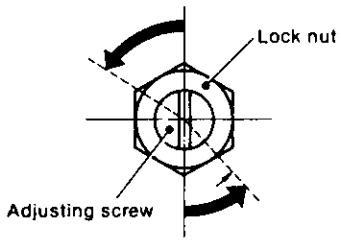
Intake and exhaust valve head clearance:	0.2mm (0.0079in.)

In the case of 2GMFY, adjust the valve head clearance of the No.2 cylinder in the same manner after turning the crankshaft 180°.
In the case of 3GMFY, adjust the valve head clearance on the No.3 cylinder in the same manner after turning the crankshaft 240° and then adjust the No.2 cylinder after turning the crankshaft another 240°.

NOTE: If you adjust the valve head clearance of the No. 2 cylinder first, turn the crankshaft 540°. Adjust the clearance of the No. 1 cylinder in the same manner on a 2 cylinder engine.

3-7.2 Adjusting without a feeler gauge

Set the head clearance to zero by tightening the adjusting screw, being careful not to tighten the screw too tight.
Then adjust the valve clearance to the maintenance standard by backing off the adjusting screw by the angle given below.



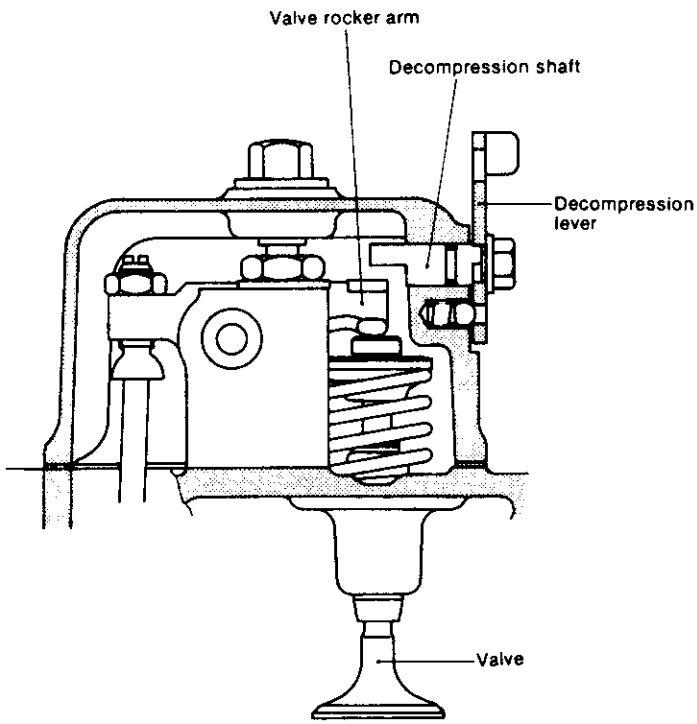
mm (in.)

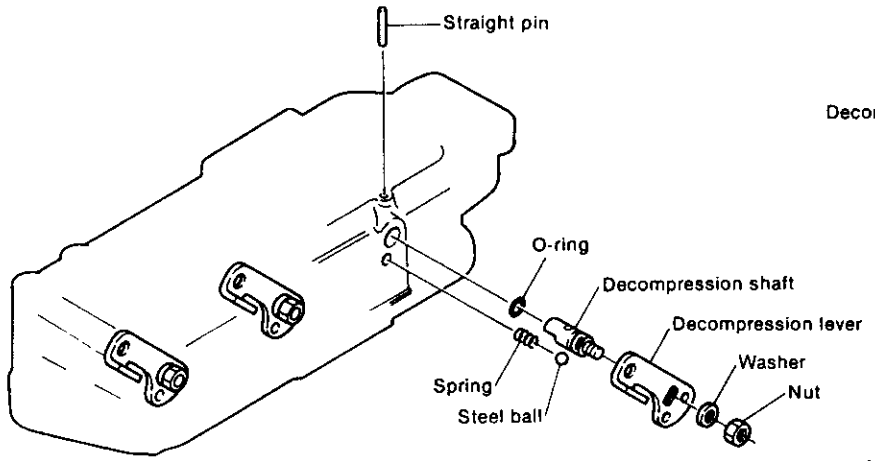
Valve clearance adjusting screw	M8 × 1.25 (0.3149 × 0.0492)
Adjusting screw backoff angle	Approx 58°

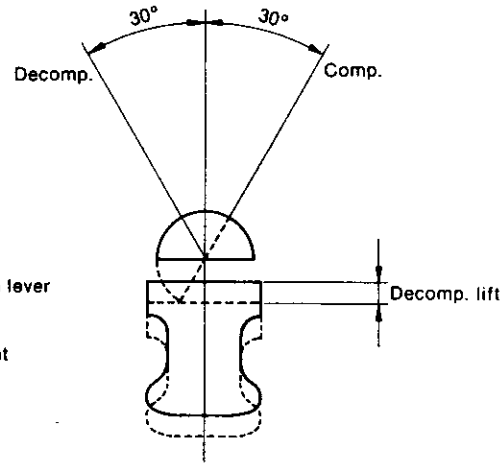
NOTE: Calculating the backoff angle.
calculate the 0.2mm advance angle from 1.25mm advance at one turn = 360°
0.2/1.25 × 360° = 58°
One side (60°) of the hexagonal nut should be used to measure.

3-8 Decompression mechanism

The decompression mechanism is used when the starter motor fails to rotate sufficiently because the battery is weak, and to facilitate starting in cold weather.
When the decompression lever is operated, the valve is pushed down, the engine is decompressed, the engine turns over easily and the flywheel inertia increases, thus making starting easy.







With this engine, there is no need to adjust the decompression lift.

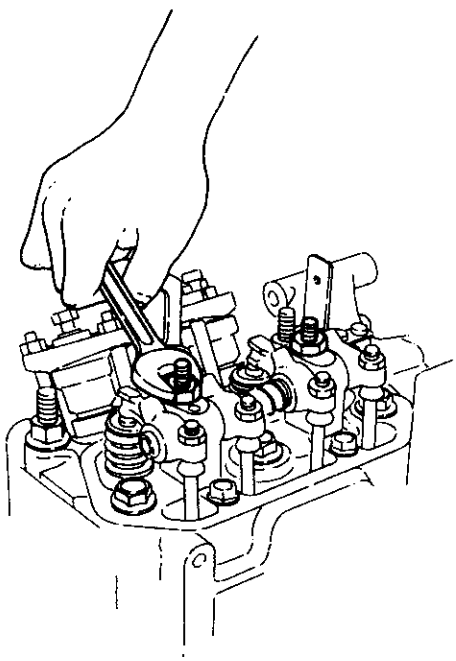
3-9 Disassembling and reassembling the cylinder head

3-9.1 Disassembling the cylinder head

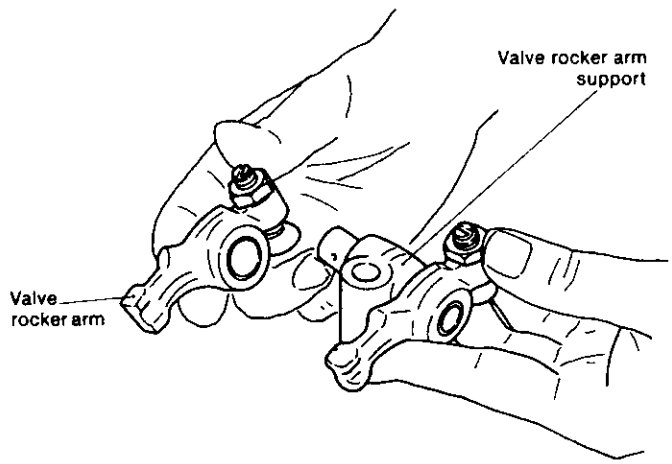
When disassembling the cylinder head, group the parts separately according to cylinder, intake or exhaust to avoid confusion.

(1) Disassembling the rocker arm ass'y

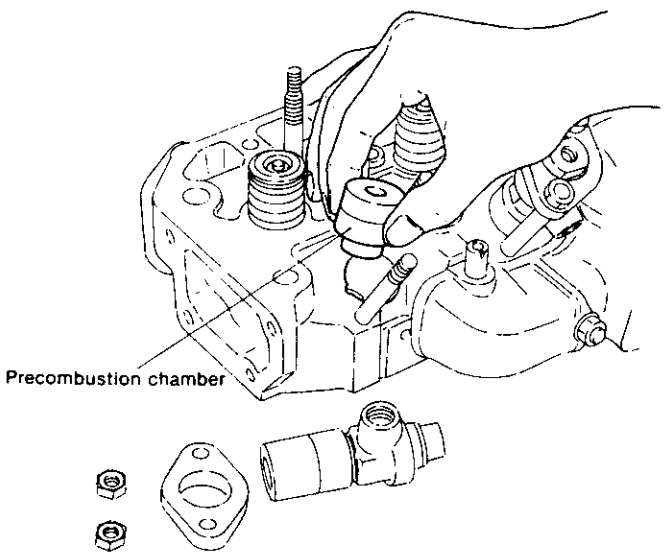
1) Remove the rocker arm ass'y mounting nuts.
2) Remove the rocker arm ass'y.



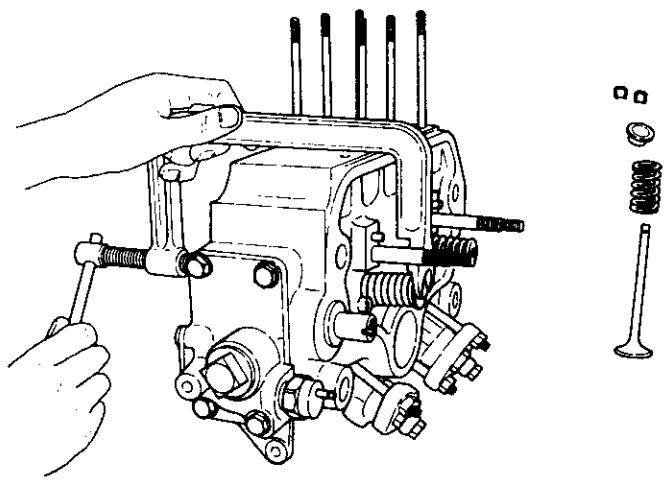
3) Remove the rocker arm retainer, and pull the rocker arm from the rocker arm support.



(2) Removing the precombustion chamber
1) Remove the rear precombustion chamber and packing.
2) Remove the front precombustion chamber and packing.



(3) Removing the intake and exhaust valve ass'y



1) Set the special tool at the intake and exhaust valve ass'y and depress the valve spring by turning the lever.
2) When the special tool is not available, depress the valve spring with a wrench.
3) Remove the spring cotter pin.
4) Turn the lever of the special tool in the loosening direction, release the valve spring retainer, and remove the valve spring retainer and valve spring.
5) Pull the valve from the cylinder head.
6) Remove the valve stem seal.
7) Remove the valve guide.

3-9.2 Reassembling the cylinder head

Before reassembling the cylinder head, wash all the parts, inspect and measure the dimensions of each part, and repair or replace any parts that are abnormal. Be careful not to confuse the parts grouped by cylinder number and intake or exhaust.

(1) Assembling the intake and exhaust valves
1) Press the valve guide into the cylinder head.
2) Install the valve stem seal. (Always replace the valve stem seal with a new seal.)
3) Install the valve in the cylinder head.
4) Install the valve spring and valve spring seat.
5) Install the split collar.
- Using the special tool
- Using a wrench

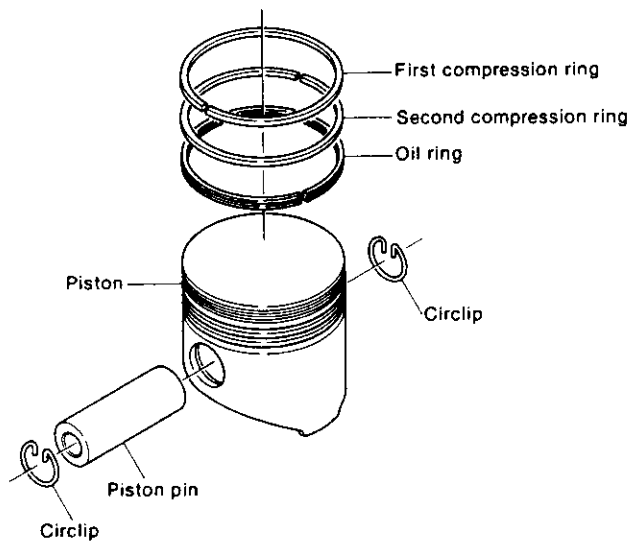
(2) Installing the valve arm ass'y
1) Install the intake and exhaust rocker arms on the rocker arm support.
2) Install both the rocker arm supports and rocker arm retainers on the cylinder head, then tighten them with nuts.

(3) Installing the precombustion chamber
1) Install the front precombustion chamber and packing.
2) Install the rear precombustion chamber and packing. (Always replace the insulation packing.)

4. Piston

4-1 Piston assembly construction

The pistons are made of LO-EX (AC8A-T6) for lightness and are designed for reduced vibration. The outside of the piston is machined to a special oval shape. During operation, thermal expansion is small, the optimum clearance between the piston and cylinder liner is maintained, and a stable supply of lubricating oil is assured.

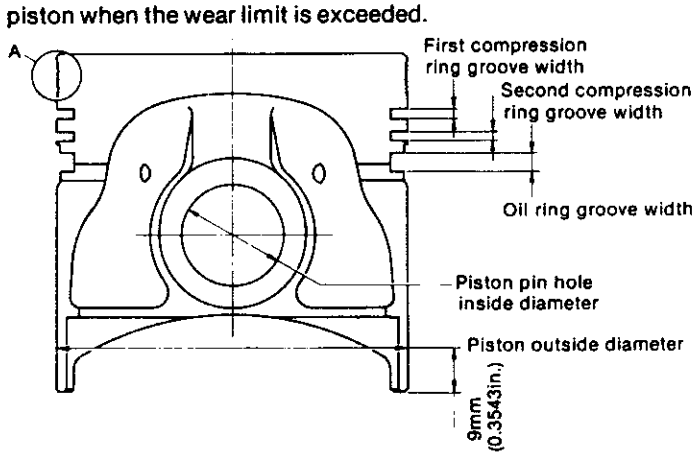


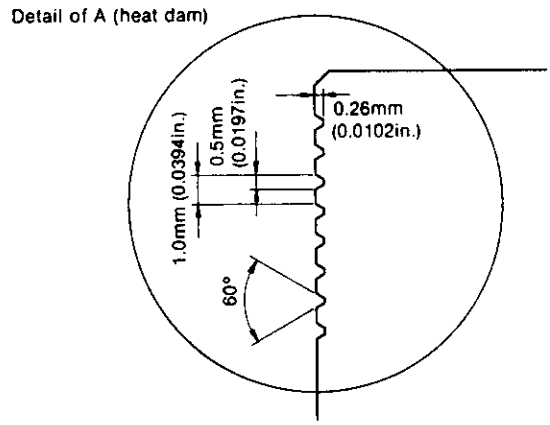
A complete set of piston rings consists of two compression rings and one oil ring.
To improve the rigidity of the piston skirt no ring is installed on the skirt itself so that the piston seldom becomes deformed and retains stable contact.
The piston pin is of the floating type. Both its ends are fastened with circlips.
Grooves called a heat dam are cut round the top section of the piston. These grooves help to dissipate heat and prevent scuffing.

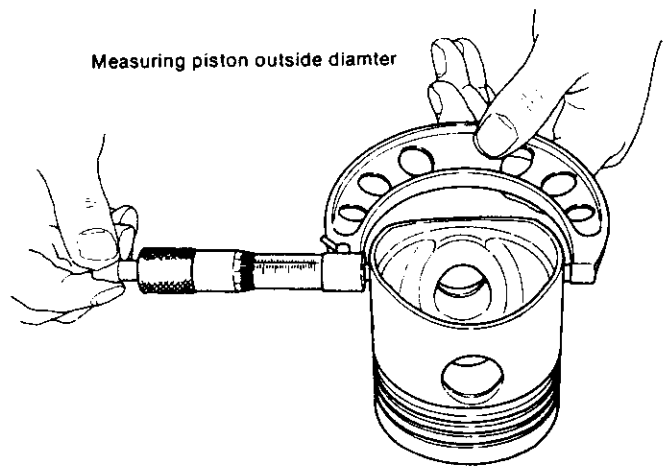
4-2 Piston

4-2.1 Inspection

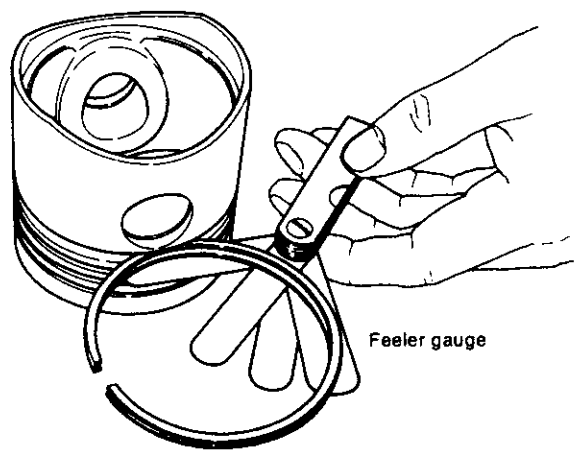
(1) Measuring important dimensions
Measure each important dimension, and replace the piston when the wear limit is exceeded.

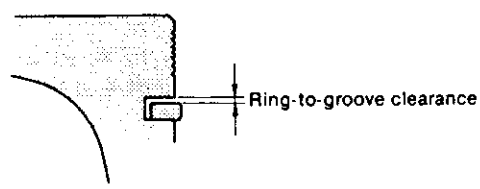






(2) Measure the clearance between the piston ring or oil ring and the ring groove with a thickness gauge.

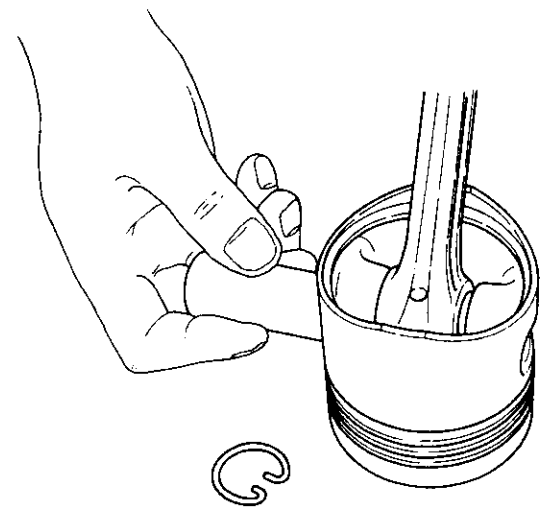




mm (in.)

	Maintenance standard	Wear limit
Piston outside diameter (At right angles to the piston pin, at a point 9.0mm (0.3543in.) from the bottom	$\phi 72^{-0.057}_{-0.087}$ (2.8312 ~ 2.8324)	71.85 (2.8287)
Piston pin hole inside diameter	$\phi 20^{+0.008}_{-0.005}$ (0.7872 ~ 0.7877)	—
First compression piston ring-to-groove clearance	0.06 ~ 0.10 (0.0024 ~ 0.0039)	0.20 (0.0079)
Second compression piston ring-to-groove clearance	0.035 ~ 0.07 (0.0014 ~ 0.0028)	0.20 (0.0079)
Oil ring-to-groove clearance	0.02 ~ 0.055 (0.0008 ~ 0.0022)	0.15 (0.0059)

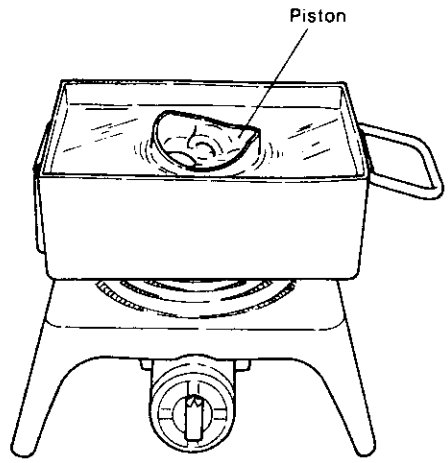
(3) Piston pin outside contact and ring groove carbon build-up.
check if the piston ring grooves are clogged with carbon, if the rings move freely, and for abnormal contact around the outside of the piston. Repair or replace the piston if faulty.



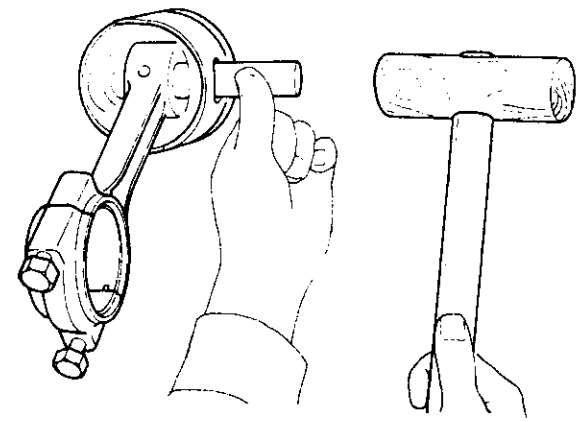
4-2.2 Replacing a piston

If the dimension of any part is worn past the wear limit or outside of the piston is scored, replace the piston.

(1) Replacement
1) Install the piston pin circlip at one side only.
2) Immerse the piston in 80°C oil for 10 ~ 15 minutes.



3) Remove the piston from the hot oil and place it on a bench with the piston head at the bottom.
4) Insert the small end of the connecting rod into the piston, insert the piston pin with a rotating motion, and install the other piston pin circlip.
Use wooden hammer if necessary.

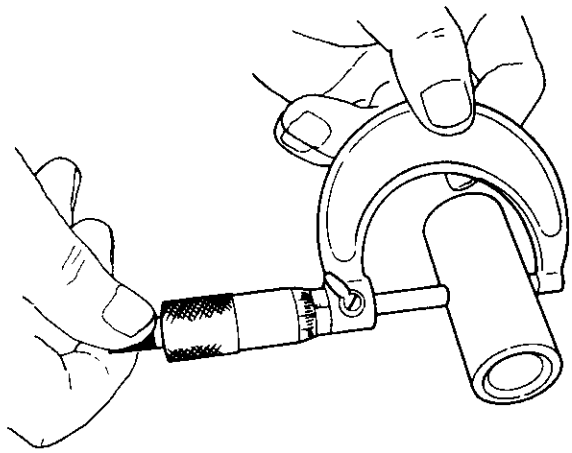


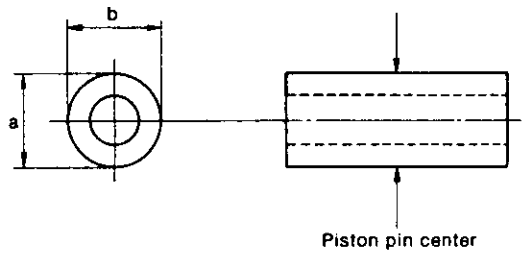
(2) Precautions
1) Before inserting, check whether the piston pin is in the connecting rod.
2) Coat the piston pin with oil to facilitate insertion.
3) Check that the connecting rod and piston move freely.
4) Insert the pin quickly, before the piston cools.

4-3 Piston pin and piston pin bushing

4-3.1 Piston pin

Measure the dimensions of the piston pin, and replace the pin if it is worn past the wear limit or severely scored.





Maximum wear measured in (a) (b) directions at central position marked*

mm (in.)

	Maintenance standard	Wear limit
Piston pin outside diameter	ø20 $^{0}_{-0.009}$ (0.7870 ~ 0.7874)	ø19.98 (0.7866)
Piston pin hole and piston pin tightening allowance	−0.005 ~ +0.017 (−0.0002 ~ +0.0007)	—

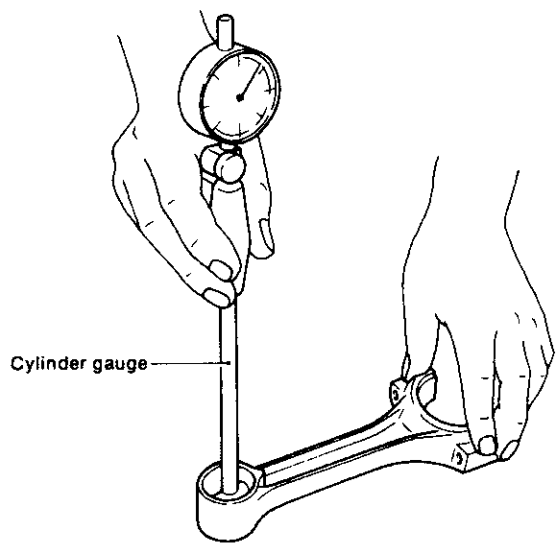
4-3.2 Piston pin bushing

A copper alloy wound bushing is pressed onto the piston pin.
Since a metallic sound will be produced if the piston pin and piston pin bushing wear is excessive, replace the bushing when the wear limit is exceeded.
The piston pin bushing can be easily removed and installed with a press. However, when installing the bushing, be careful that it is not tilted.

mm (in.)

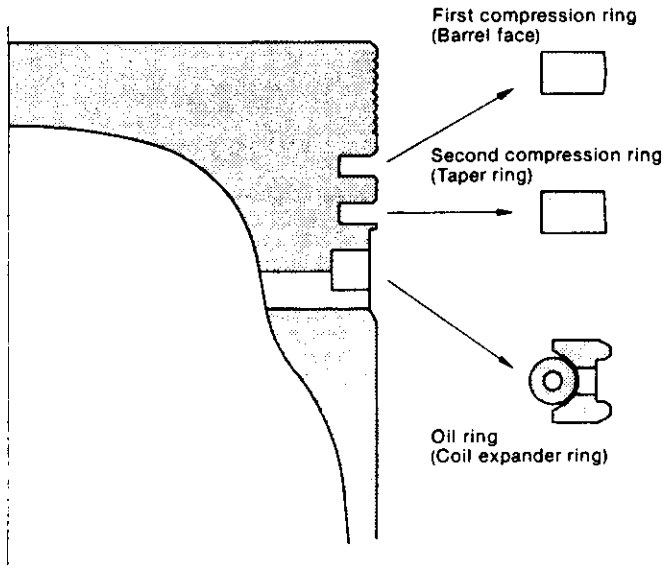
	Maintenance Standard	Wear limit
Piston pin bushing inside diameter	ø20.0 (0.7874)	ø20.1 (0.7913)

NOTE: "Piston pin bushing inside diameter" is the dimension after pressing onto the connecting rod.

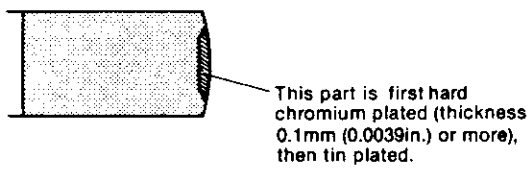


4-4 Piston rings

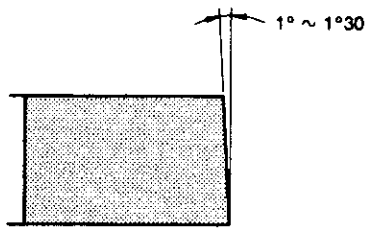
4-4.1 Piston ring configuration



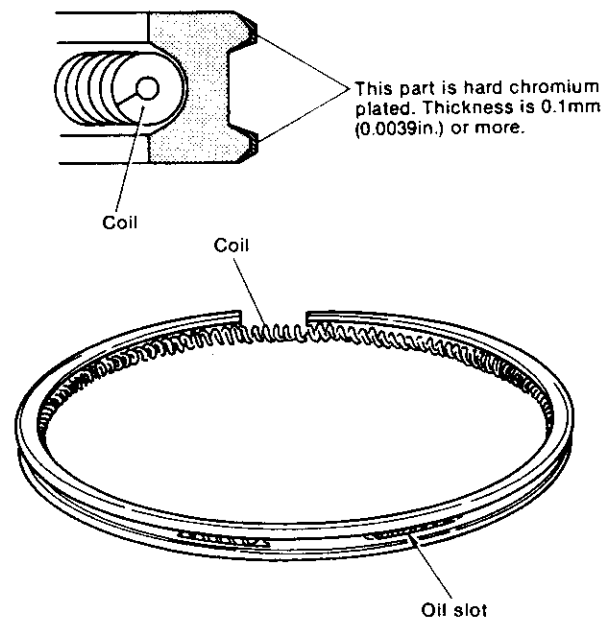
(1) The first compression ring is a barrel face ring that effectively prevents abnormal wear caused by engine loading and combustion gas blowby at initial run-in.
The sliding surface is hard chromium plated.



(2) The second compression ring is a taper ring having a sliding face taper of 30′ ~ 1°30′. Since the cylinder liner is straight, and the contact area at initial operation is small, it is easily seated to the cylinder liner.
Moreover, the bottom of the sliding face is sharp, and oil splash is excellent and air-tightness is superb.



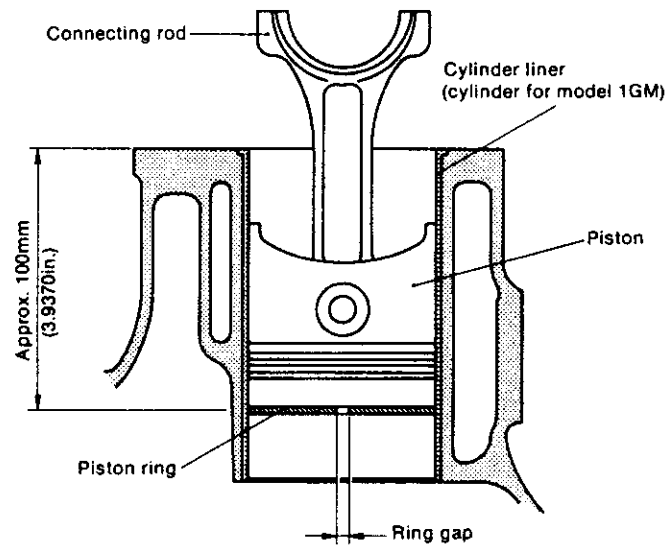
(3) The oil ring is a chrome-plated coil expander having a small contacting face, and exerts high pressure against the cylinder liner wall. Oil splash at the bottom of the sliding face is excellent, and its oil control effect is high.

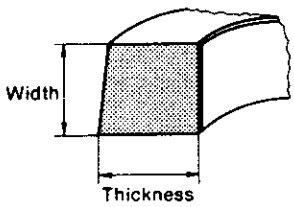


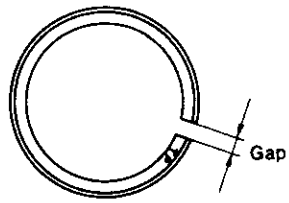
4-4.2 Inspection

(1) Piston ring contact
Inspect the piston ring contact, and replace the ring when contact is faulty. Since the oil ring side contact is closely related to oil consumption, it must be checked with particular care.

(2) Measuring the piston ring gap
Insert the piston into the cylinder or cylinder liner by pushing the piston ring at the head of the piston as shown in the figure, and measure the piston ring gap with a feeler gauge. Measure the gap at a point about 100mm (3.9370in.) from the top of the cylinder.
Measure by inserting a thickness gauge





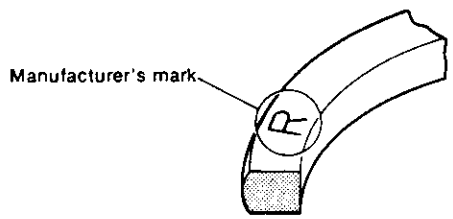


mm (in.)

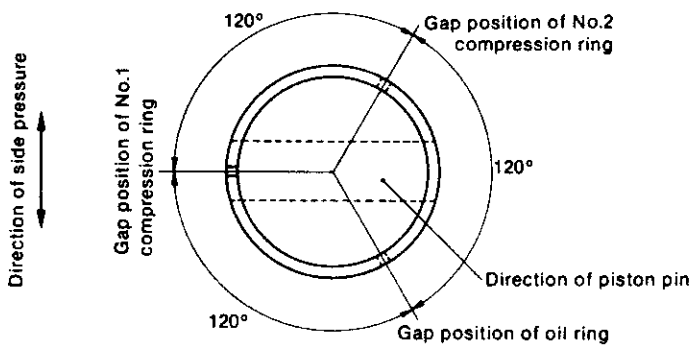
		Maintenance standard	Wear limit
Piston ring (1, 2)	Width	$2^{-0.01}_{-0.03}$ (0.0776 ~ 0.0783)	1.90 (0.0748)
	Thickness	$3.2^{\pm 0.10}$ (0.1220 ~ 0.1299)	—
Oil ring	Width	$4^{-0.01}_{-0.03}$ (0.1563 ~ 0.1181)	3.90 (0.1535)
	Thickness	$2.8^{\pm 0.20}$ (0.1024 ~ 0.1181)	—
Piston ring gap (1, 2)		0.20 ~ 0.40 (0.0079 ~ 0.0157)	1.5 (0.0591)
Oil ring gap		(0.20 ~ 0.40 (0.0079 ~ 0.0157)	1.5 (0.0591)

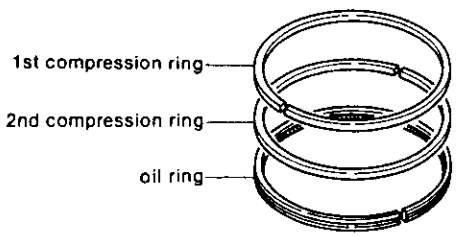
(3) Piston ring replacement precautions

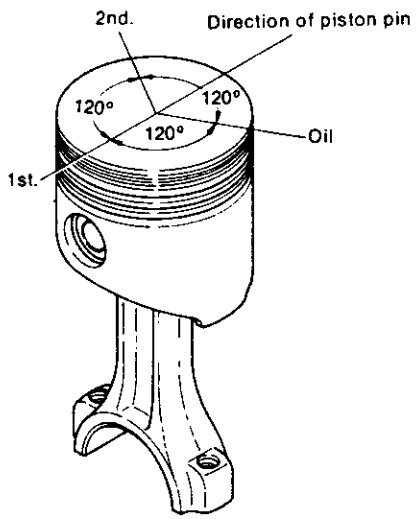
1) Clean the ring grooves carefully when replacing the rings.
2) When installing the rings, assemble the rings so that the manufacturer's mark near the gap is facing the top of the piston.



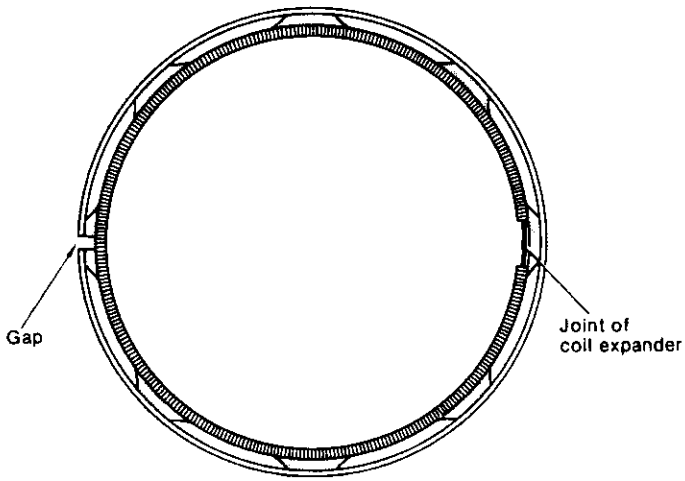
3) After assembly, check that the rings move freely in the grooves.
4) The rings must be installed so that the gaps are 120° apart. At this time, be careful that the ring gap is not lined up with the piston side pressure part.







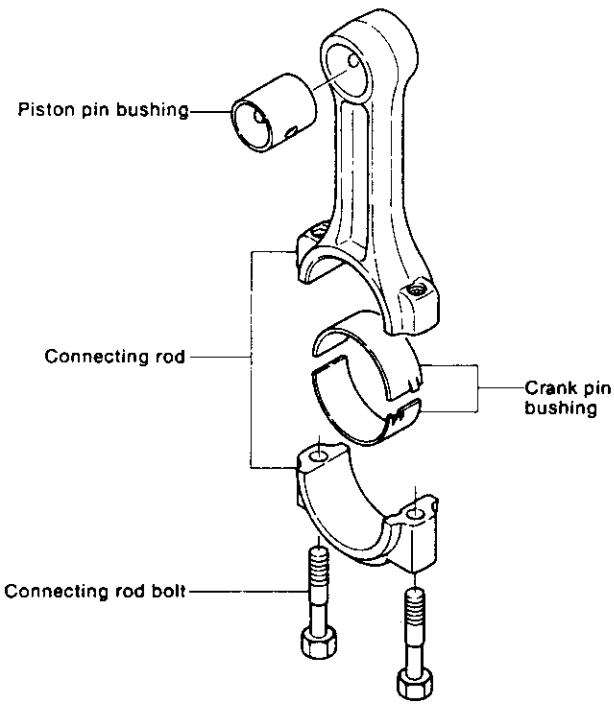
5) Since the oil ring is equipped with a coil expander, attach it to the piston so that the joint of the ring is opposite the gap of the coil expander.



5. Connecting Rod

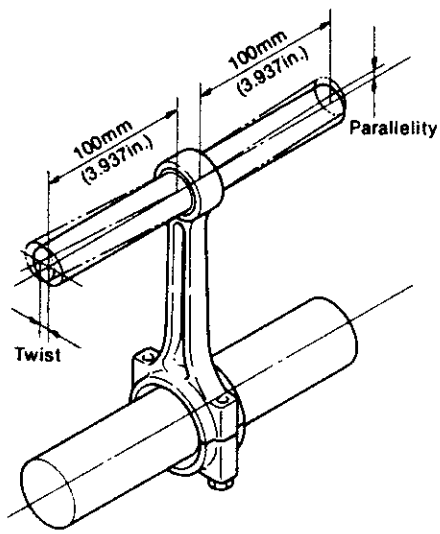
5-1 Connecting rod ass'y construction

The connecting rod connects the piston pin and crank pin and transmits the explosive force of the piston to the crankshaft. It is a stamp forging designed for extreme lightness and ample strength against bending. A kelmet bushing split at right angles is installed to the large end of the rod, and a round copper alloy is pressed onto the small end.



5-2 Inspection

5-2.1 Large and small end twist and parallelity

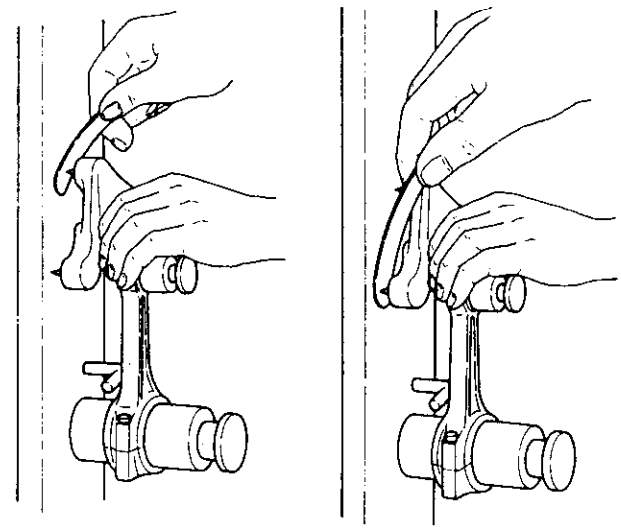


Pass a test bar through the large end and small end holes of the connecting rod, place the bars on a V-block on a stool and center the large end test bar. Then set the sensor of a dial indicator against the small end test bar and measure twist and parallelity. When the measured value exceeds the wear limit, replace the connecting rod. Twisting and poor parallelity will cause uneven contact of the piston and bushing and shifting of the piston rings, resulting in compression leakage.

Connecting rod twist and parallelity

mm (in.)

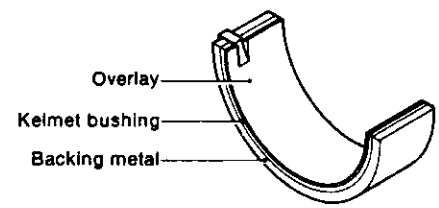
Maintenance standard	0.03/100 or less (0.00118/3.937)
Limit	0.08/100 (0.00315/3.937)



Measuring twist and parallelity

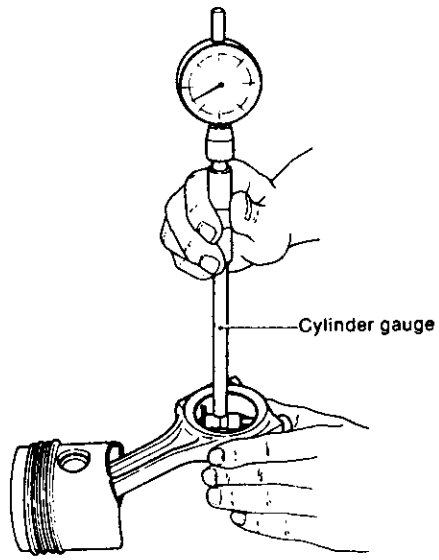
5-3 Crank pin bushing

Since the crank pin bushing slides while receiving the load from the piston, an easy-to-replace kelmet bushing with a wear-resistant overlay is used.



5-3.1 Crank pin bushing inside diameter

Tighten the large end of the connecting rod to the prescribed torque with the connecting rod bolts, and measure the inside diameter of the crank pin bushing. Replace the bushing if the inside diameter exceeds the wear limit or the clearance at the crank pin part exceeds the wear limit.



mm (in.)

	Maintenance standard	Wear limit
Crank pin bushing inside diameter	ø40.0 (1.5748)	ø40.10 (1.5787)
Crank pin and bushing oil clearance	0.028~0.086 (0.0011 ~0.0034)	0.13 (0.0051)
Connecting rod bolt Thread diameter	M7 × P1.0 (0.2755 × 0.0393)	
Connecting rod bolt tightening torque	2.5 kgf-m (18.1 ft-lb)	

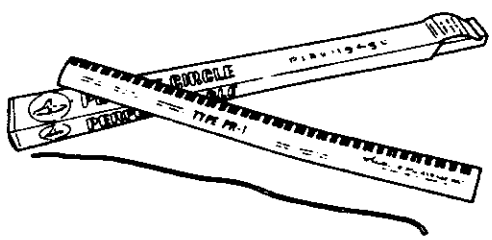
NOTE: The crank pin bushing inside diameter must always be measured with the connecting rod bolts tightened to the prescribed torque.

5-3.2 Crank pin and bushing clearance (oil clearance)

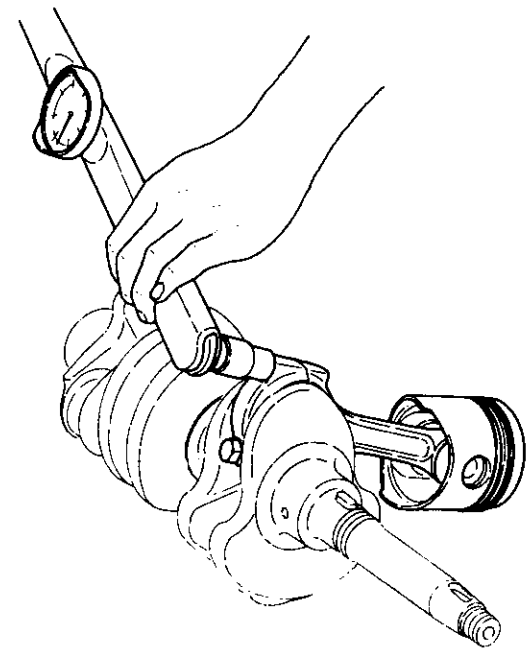
Since the oil clearance affects both the durability of the bushing and lubricating oil pressure, it must always be the prescribed value. Replace the bushing when the oil clearance exceeds the wear limit.

(1) Measurement

1) Thoroughly clean the inside surface and crank pin section of the crank pin bushing.
2) Install the connecting rod on the crank pin section of the crankshaft and simultaneously fit a Plasti gauge on the inside surface of the crank pin bearing.

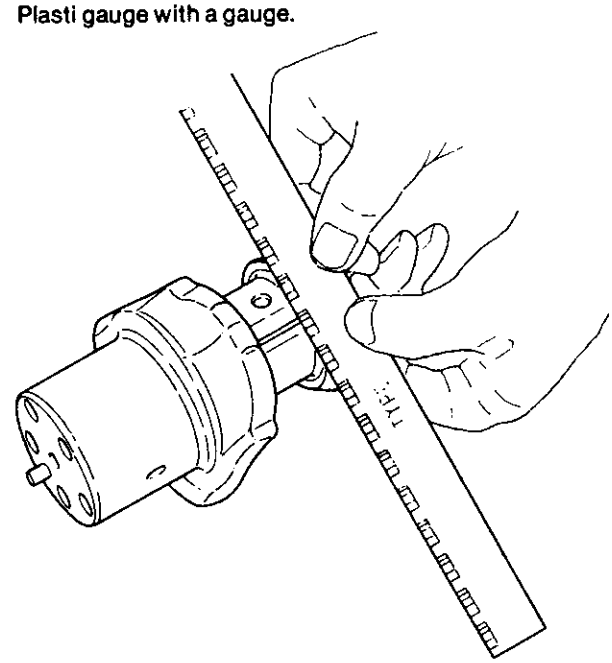


3) Tighten the connecting rod bolt to the prescribed tightening torque.



Connecting rod tightening torque	2.5 kgf-m (18.1 ft-lb)
Hexagon width	12mm (0.4724in.)

4) Loosen the connecting rod bolt and slowly remove the connecting rod big end cap, then measure the crushed Plasti gauge with a gauge.



NOTE: Never adjust by shims or machine the crank pin bushing. Always replace the crank pin bushing with a new one.

5) The crank pin and bushing clearance (oil clearance) may also be measured with a micrometer, in addition to measurement with a Plasti gauge. With this method, the outside diameter of the crankshaft crank pin section and the inside diameter of the connecting rod's big end bushing, when the connecting rod bolt has been tightened to the prescribed torque, are measured, and the difference between the large end bushing inside diameter and crank pin outside diameter is set as the oil clearance.

(2) Measurement precautions

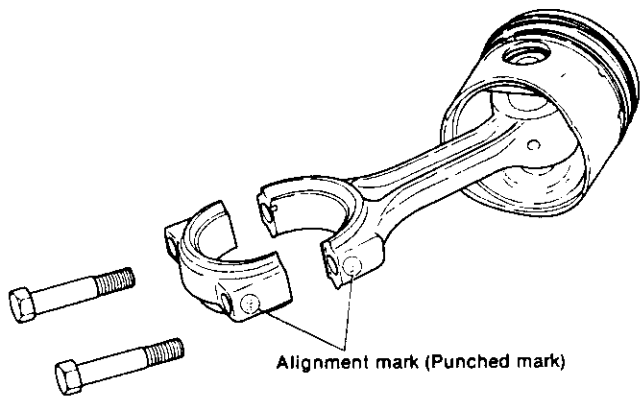
1) Be careful that the Plasti gauge does not enter the crank pin oil hole.
2) Be sure that the crankshaft does not turn when tightening the connecting rod bolt.

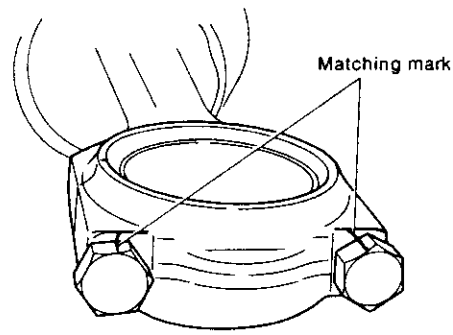
5-3.3 Crank pin bushing replacement precautions

(1) Thoroughly clean the crank pin bushing and the rear of the crank pin bushing.

(2) Also clean the big end cap, and install the crank pin bushing and check if the bushing contacts the big end cap closely.

(3) When assembling the connecting rod, match the number of the big end section and the big end cap, coat the bolts with engine oil, and alternately tighten the bolts gradually to the prescribed tightening torque. If a torque wrench is not available, put matching marks (torque indication lines) on the bolt head and big end cap before disassembly and tighten the bolts until these two lines are aligned.



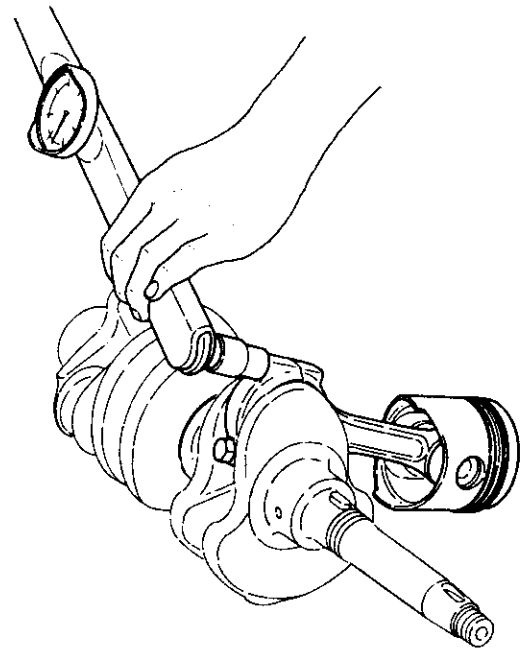


(4) Check that there is no sand or metal particles in the lubricating oil and that the crankshaft is not pitted. Clean the oil holes with particular care.

5-4 Tightening the connecting rod bolts

When tightening the connecting rod bolts, coat the threads of the bolts with engine oil.

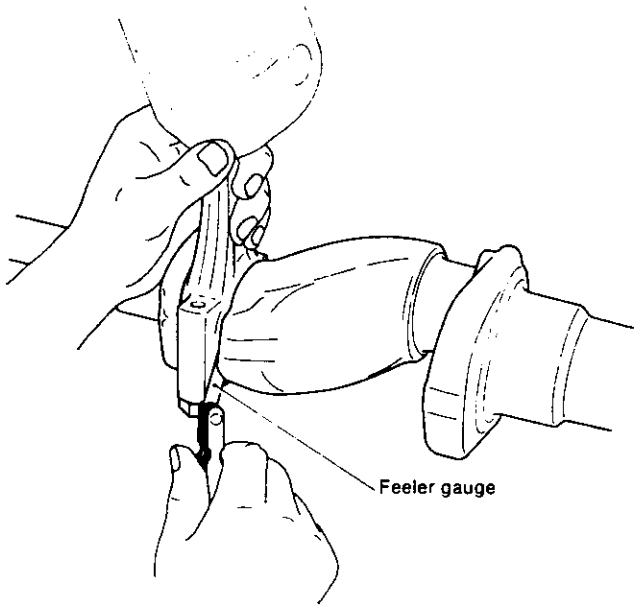
Tighten the two bolts alternately and gradually to the prescribed tightening torque. If a torque wrench is not available, make matching marks (torque indication lines) on the head of the bolt and the big end cap and tighten the bolts until these two marks are aligned.



5-5 Connecting rod side clearance

After installing the connecting rod on the crankshaft, push the rod to one side and measure the side clearance by inserting a feeler gauge into the gap produced at the other side.

The connecting rod bolts must also be tightened to the prescribed tightening torque in this case.

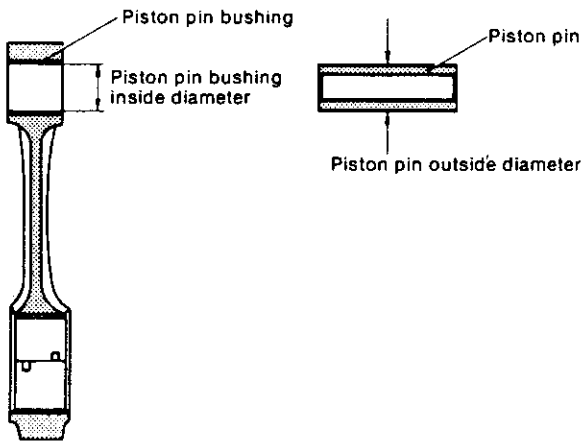


mm (in.)

Connecting rod side clearance	0.2 ~ 0.4 (0.0079~0.0157)

5-6 Piston bushing and piston pin

The piston bushing is a round copper alloy bushing driven onto the small end of the connecting rod. During use, the piston pin bushing and piston pin will wear. If this wear becomes excessive, a metallic sound will be produced and the engine will become noisy.

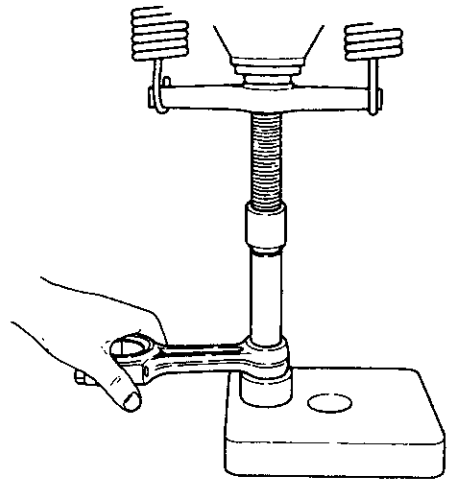


mm (in.)

	Maintenance standard	Wear limit
Piston pin bushing inside diameter	ø20.0 (0.7874)	ø20.10 (0.7913)
Piston and bushing clearance	0.025~0.047 (0.0010 ~0.0019)	0.11 (0.0043)

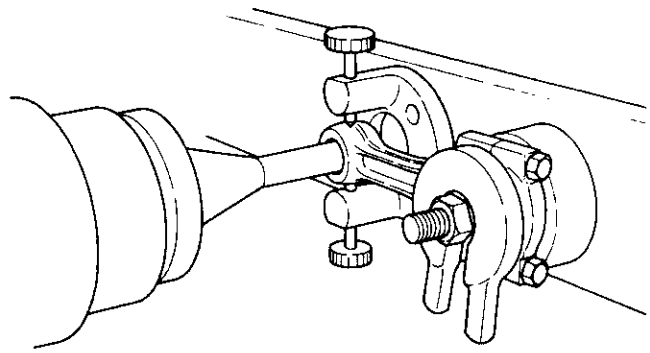
Replacing the piston pin bushing

(1) When the bushing for the connecting rod piston pin is either worn out or damaged, replace it by using the "piston pin extracting tool" installed on a press.



NOTE: Force the piston pin bushing into position so that its oil hole coincides with the hole on the small end of the connecting rod.

(2) After forcing the piston pin bushing into position, finish the inner surface of the bushing by using a pin honing machine or reamer so that it fits the piston pin to be used.



NOTE: Attach the bushing to the piston pin so that a pin, coated with engine oil can be pushed into position with your thumb.

6. Crankshaft

6-1 Crankshaft ass'y and bearing construction

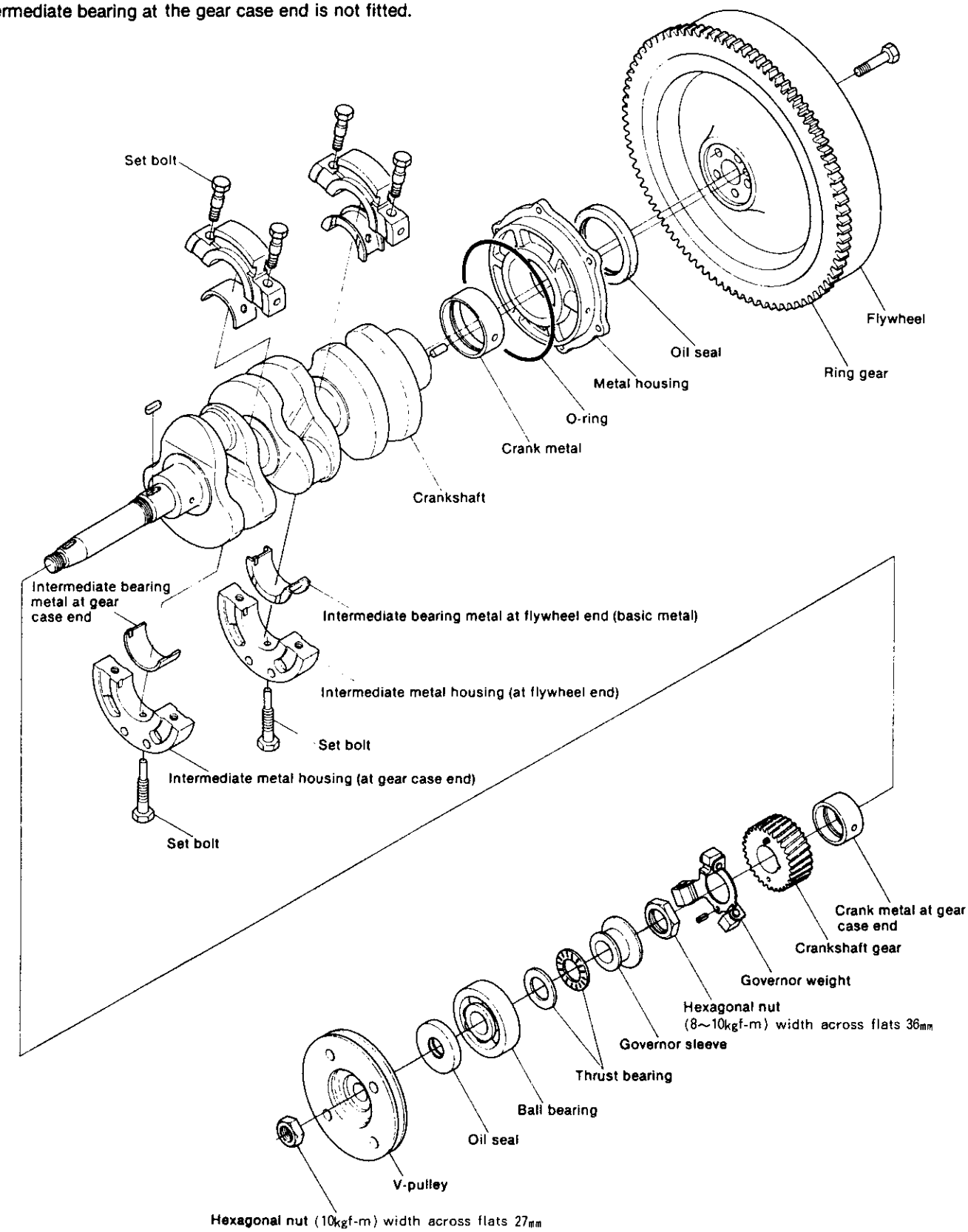
The crankshaft is stamp-forged, and the crank pin and journal sections are high-frequency induction hardened; and ground and polished to a high precision finish. Therefore, the contact surface with the bushing is excellent and durability is superb.

The crankshaft is a balance weight integral type. Engine unbalance, which causes vibration, has been minimized by balancing the V-pulley, flywheel, and crankshaft.

The flywheel is fixed at the end of the crankshaft with hexagonal bolts and a locating pin. The crankshaft gear is fixed and keyed to the crankshaft inside the timing gear case, and the governor weight support is fixed with a hexagonal nut together with the crankshaft gear. It is so designed that the governor sleeve and the thrust bearing can be slid onto the crankshaft to get the gear side end of the crankshaft to perform as the governor shaft. The V-pulley is fitted outside the timing gear case and it drives the alternator and cooling water pump.

6-1.2 Construction of crankshaft assembly

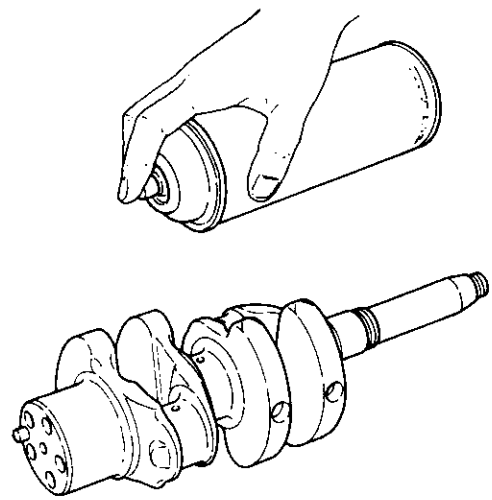
The following figure shows the crankshaft assembly the intermediate bearing at the gear case end is not fitted.



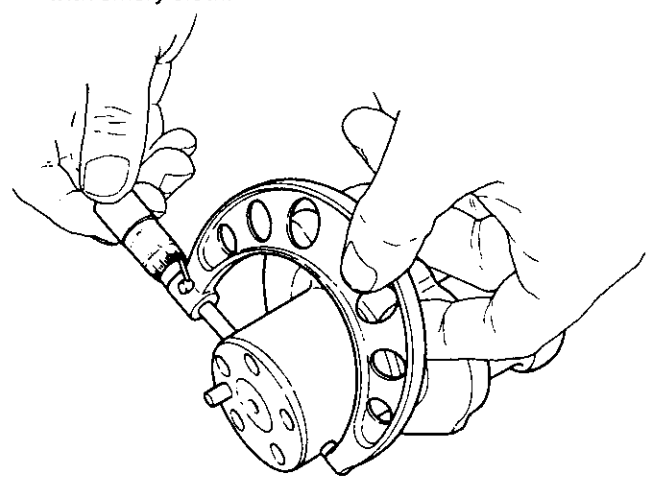
6-2 Inspection

6-2.1 Crank journal and crank pin

(1) Cracking
If cracking of the crank journal or crank pin is suspected, thoroughly clean the crankshaft and perform a color check on the shaft, or run a candle flame over the crankshaft and look for oil seepage from cracks. If any cracks are detected, replace the crankshaft.



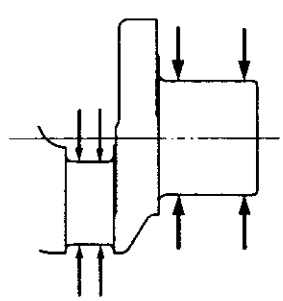
(2) Crank pin and crank journal outside diameter measurement.
When the difference between the maximum wear and minimum wear of each bearing section exceeds the wear limit, replace the crankshaft. Also check each bearing section for scoring. If the scoring is light, repair it with emery cloth.

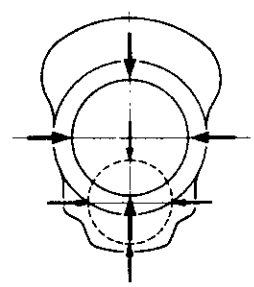


mm (in.)

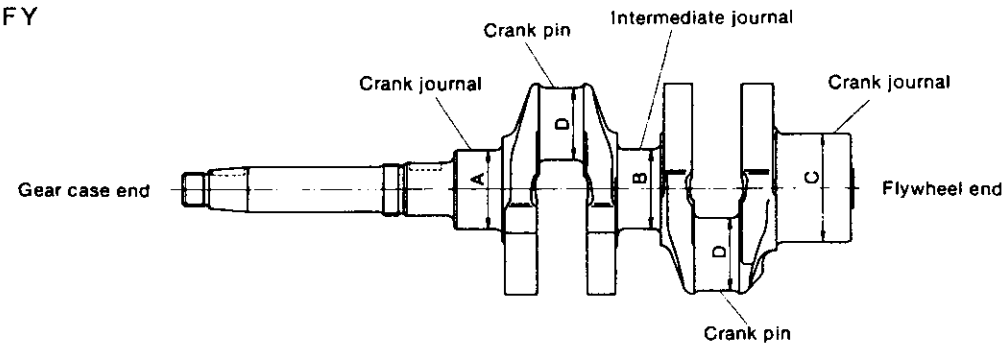
			Maintenance standard	Wear limit
Crank journal outside diameter	Gear case side	A	$\phi 44^{-0.036}_{-0.050}$ (1.7303 ~ 1.7309)	ø43.90 (1.7283)
	Intermediate bearing	B	$\phi 44^{-0.036}_{-0.050}$ (1.7303 ~ 1.7309)	ø43.90 (1.7283)
	Flywheel side	C	$\phi 60^{-0.036}_{-0.050}$ (2.3602 ~ 2.3608)	ø59.90 (2.3583)
Crank pin outside diameter		D	$\phi 40^{-0.036}_{-0.050}$ (1.5728 ~ 1.5734)	ø39.90 (1.5709)
Crank journal/pin eccentric wear			—	0.01 (0.0004)
Crank journal and bushing oil clearance	Gear case side		0.036 ~ 0.092 (0.0014 ~ 0.0036)	0.15 (0.0059)
	Intermediate bearing		0.036 ~ 0.092 (0.0014 ~ 0.0036)	0.15 (0.0059)
	Flywheel side		0.036 ~ 0.095 (0.0014 ~ 0.0037)	0.15 (0.0059)
Crank pin and crank pin bearing oil clearance			0.028 ~ 0.086 (0.0011 ~ 0.0034)	0.13 (0.0051)

Measurement must be taken in at least 2 positions in the direction of crankshaft center line for each journal, and in each measurement, maximum and minimum wear directions must be measured. From these results, eccentric wear and maximum wear can be determined.

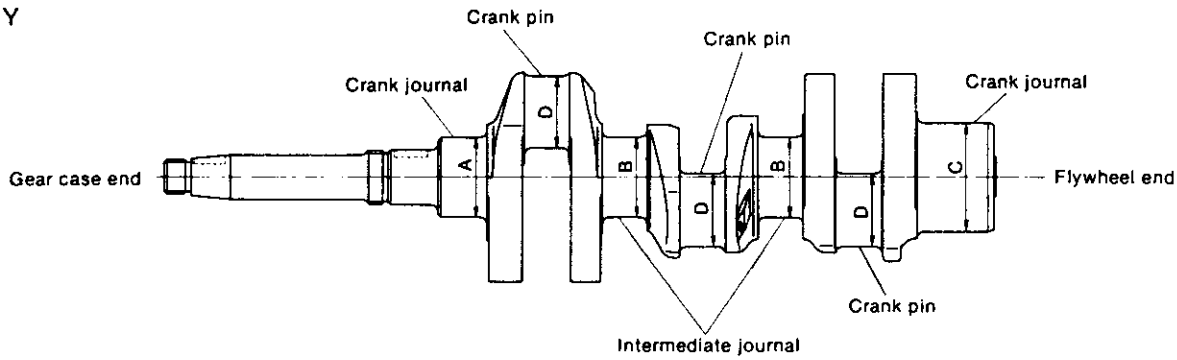




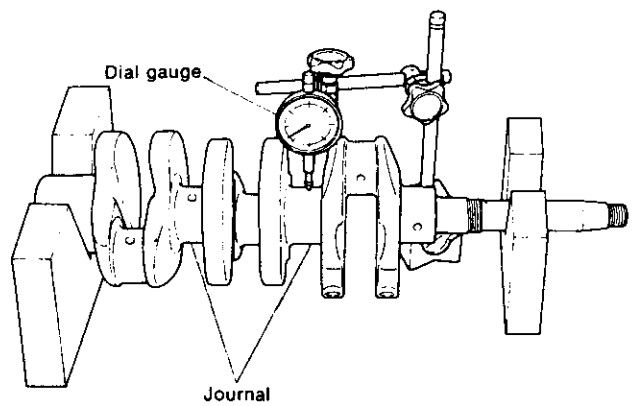
2GMFY

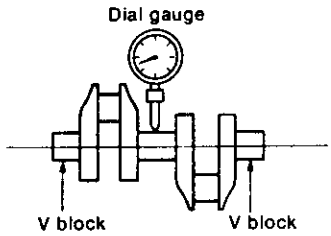


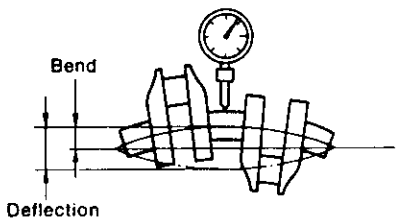
3GMFY



(3) Measuring the crankshaft bend
Measure on a surface plate. Place the journal parts of both ends of the crankshaft on a V-block and measure with a dial gauge while moving the crankshaft in an axial direction. If the deflection of the middle of the crankshaft exceeds the limit, replace the crankshaft.







mm (in.)

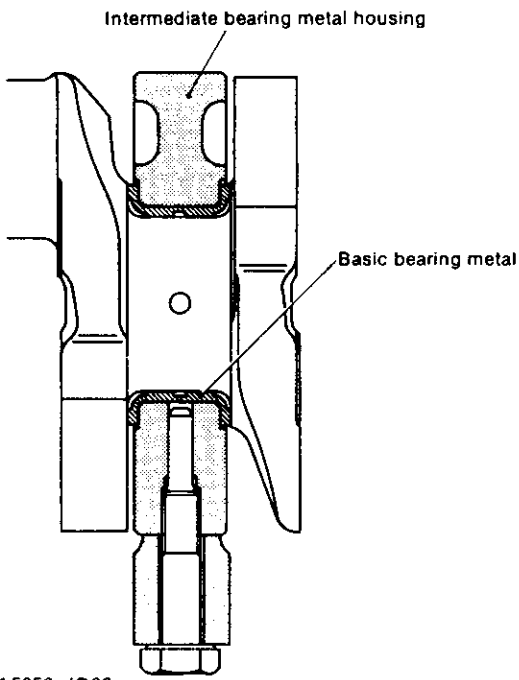
	Maintenance standard	Wear limit
Crankshaft bend	Less than 0.015 (0.0006)	0.15 (0.006)

6-3 Crankshaft side gap

6-3.1 Side gap

The clearance in the axial direction after the crankshaft has been assembled is called the side gap.
If the side gap is too large, contact with pistons will be uneven, the clutch disengagement position will change, and other troubles will occur. If it is too small, the crankshaft sliding resistance will increase and cranking will become stiff.

The value of the side gap is the difference between the width of the basic bearing metal and the width of the journal. The basic bearing for model 2GMFY is the intermediate bearing, and for models 3GMFY it is the intermediate bearing at the flywheel end.



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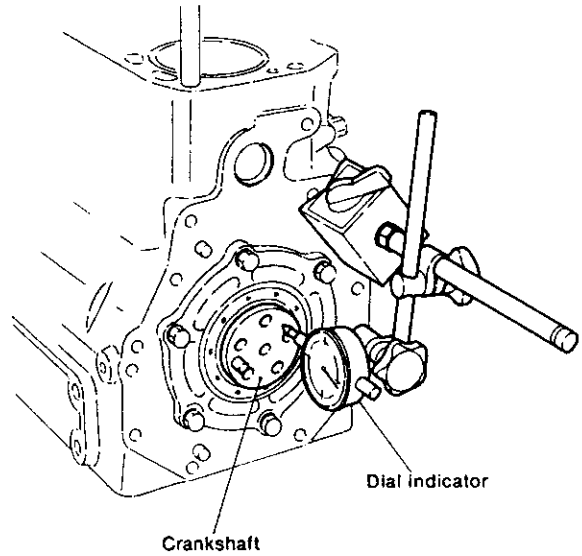
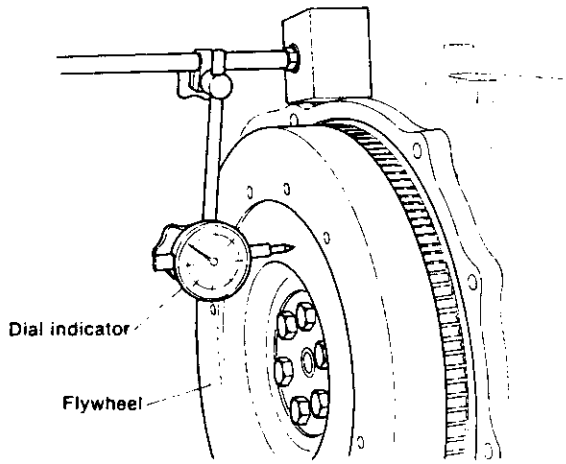
6-3.2 Measuring side gap

Set a dial indicator against the end of the crankshaft (or end of the flywheel) and measure the amount of movement of the crankshaft in the axial direction. If the measured value exceeds the wear limit, replace the crankshaft thrust washer. Main bearing housing packing of the prescribed thickness must be used.





6-3.3 Side gap maintenance standard and wear limit

mm (in.)

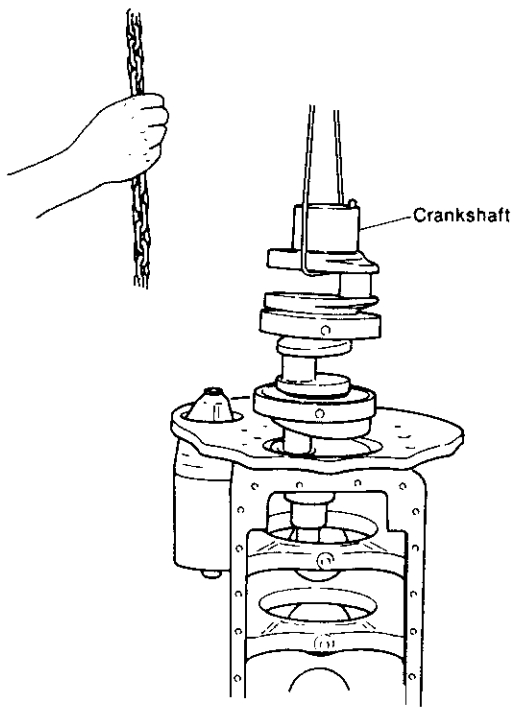
	Maintenance standard	Wear limit
Crank shaft side gap	0.09 ~ 0.19 (0.0035 ~ 0.0075)	0.30 (0.0012)

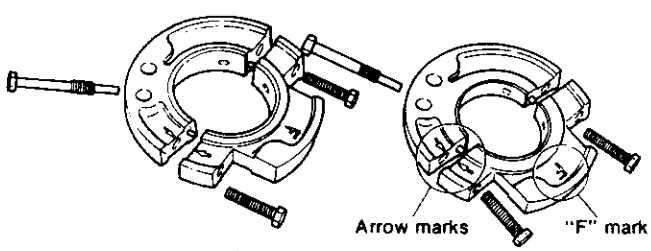
6-4 Disassembly of the crankshaft

For model 1GM see the chapter on disassembly and reassembly. Because there are points over which care must be taken disassembly and reassembly procedures are explained below.

6-4.1 Disassembly

(1) When disassembling, lay the cylinder down with the main bearing housing side on top so that the crankshaft will be vertical for easy operation.
(*Remove the crank gear and flywheel beforehand.)
(2) Remove the main bearing housing.
(3) Attach a rope to the crankshaft, gradually lifting it with chain block etc. and remove the two set bolts of the intermediate main bearing housing. (If the crankshaft is lifted too much or not enough, the set bolts will be difficult to release.)
(4) Lift and remove the crankshaft (with the intermediate main bearing housing).
(5) Remove each intermediate main bearing housing from the crankshaft.





Primary main bearing

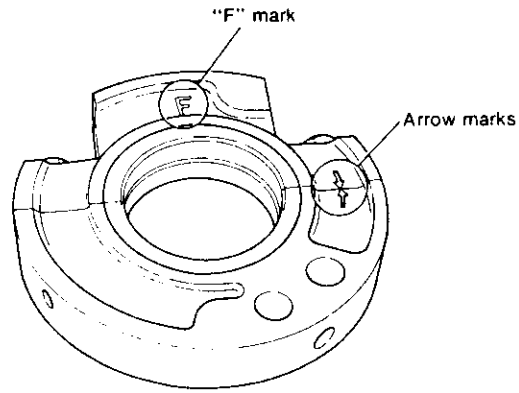
6-4.2 Reassembly

(1) Clean each part before reassembly.

(2) Attach the intermediate main bearing housing to the crankshaft and confirm that the crankshaft rotates smoothly.

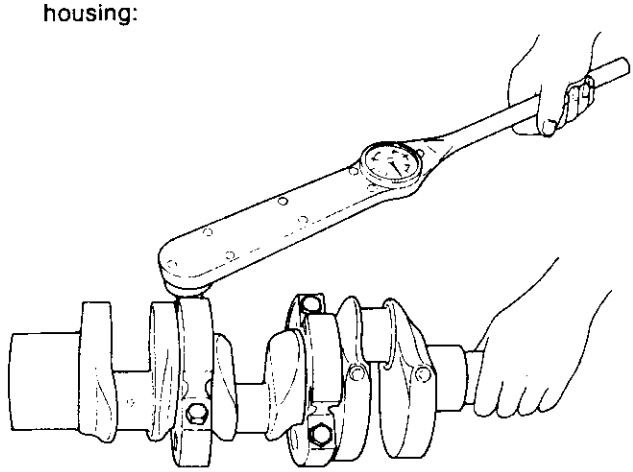
1) Assembling position and direction of the intermediate main bearing housing.

- The "F" mark on the intermediate main bearing housing indicates the direction of assembly on the crankshaft flywheel.



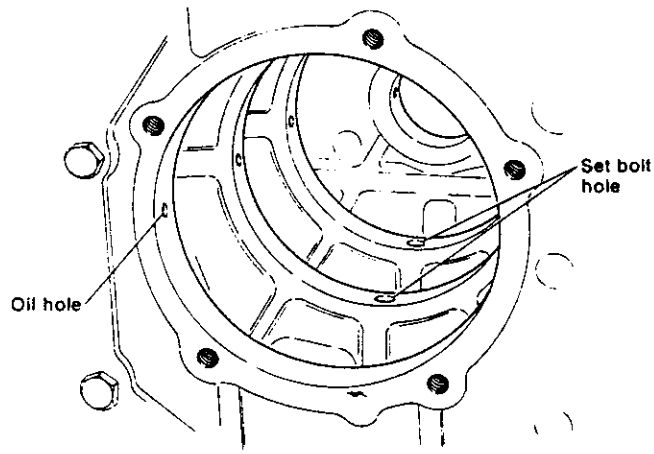
- Align the arrow marks pointing up and down on the side of the intermediate main bearing housing and assemble it so that the "F" mark is in the direction of the flywheel.
- Assemble, integrated with thrust bearing, the intermediate main bearing on the flywheel side (between cylinder No. 1 and 2).

2) Tightening torque of hexagonal bolts for affixing the top and bottom of the intermediate main bearing housing:



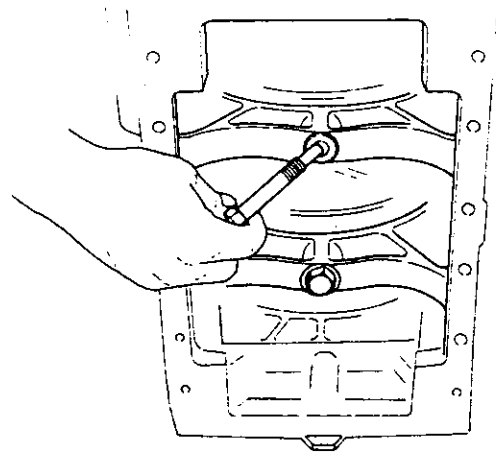
	kgf-m (ft-lb)
Tightening torque	3.0 ~ 3.5 (21.7 ~ 25.3)

(3) Set up vertically the cylinder block, suspend the crankshaft and match the positions of the cylinder block oil hole and the intermediate main bearing housing set bolts to the intermediate main bearing housing.



(4) Attaching the intermediate main bearing housing set bolts.

1) First temporarily screw the set bolt in the intermediate main bearing housing on the timing gear housing side and with the prescribed tightening torque, start tightening from the intermediate main bearing housing on the flywheel side. After tightening the bolts confirm that the crankshaft rotates smoothly. (Each set bolt hole can be adjusted vertically.)



	kgf-m (ft-lb)
Tightening torque of the set bolt	4.5 ~ 5.0 (32.5 ~ 36.2)

(5) Reassembly of the main bearing housing:

1) Enclose a small amount of oil inside the oil seal and assemble after coating the bearing with oil.

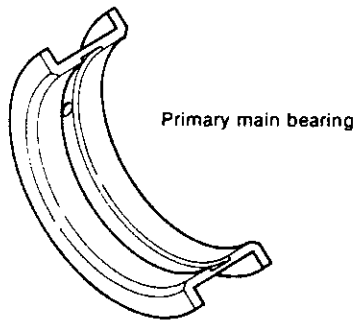
2) Be sure to place the "down" mark on the main bearing housing side in the downward direction.

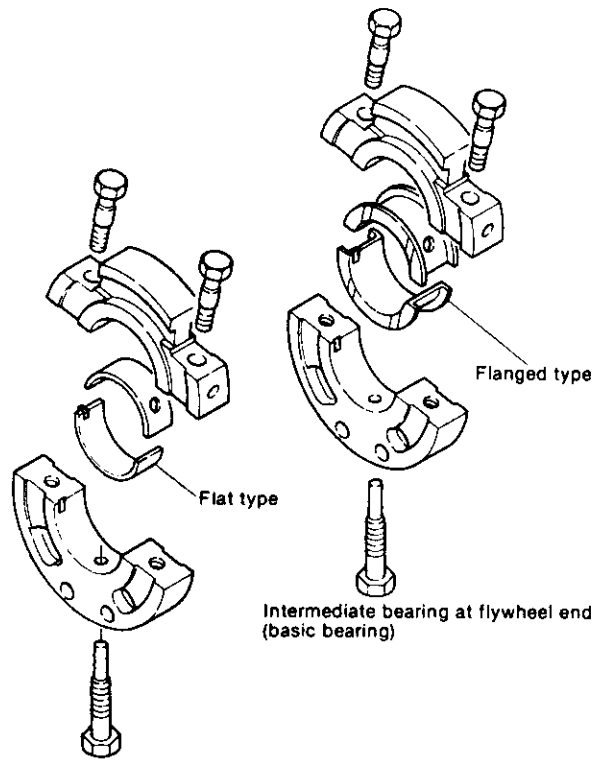
	kgf-m (ft-lb)
Main bearing housing tightening torque	2.5 (18.1)

6-5 Main bearing

6-5.1 Construction

For the intermediate main bearing on the flywheel side, a flange type bearing integrated with the thrust bearing is used. Because this is the primary main bearing, those without the thrust bearing on the sides of the flywheel and timing gear housing are whole circle bearings, while the intermediate main bearing on the timing gear housing side is the divided circle type.

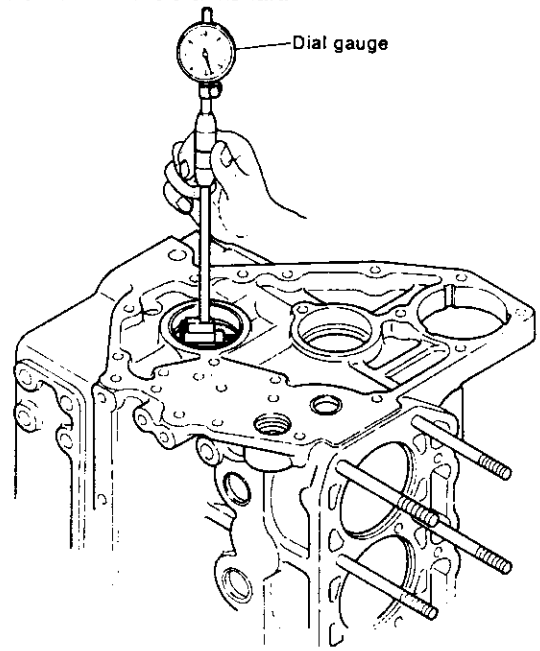


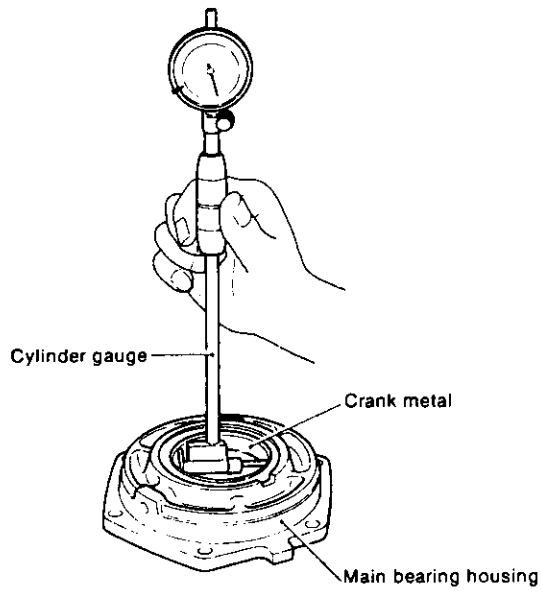


6-5.2 Inspecting the crank bearing

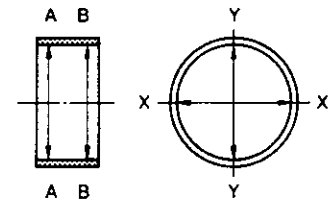
(1) Check the crank bearing metal for scaling, deposited metal and seizure. Also check the condition of the contact surface. If defects are found, replace.
If the bearing metal contact is too unsymmetrical, carefully check all related component parts which might be responsible, and take proper measures.

(2) Determine the oil clearance by measuring the inside diameter of the crankshaft bearing and the outside diameter of the crankshaft.





NOTES: 1) Measure the crank bearing at the four points shown in the figure and replace the bearing if the wear limit is exceeded at any of these points.
2) When measuring the inner diameter of the crank bearing, the crank bearing should be installed on the bearing housing and/or cylinder block.



mm (in.)

		Maintenance standard	Wear limit
Flywheel side	Main bearing inside diameter	ø60.0 (2.3622)	ø60.12 (2.3669)
	Crankshaft journal outside diameter	ø60.0 (2.3622)	ø59.90 (2.3583)
	Oil clearance	0.036 ~ 0.095 (0.0014 ~ 0.0037)	0.15 (0.0059)
Opposite side of flywheel	Main bearing inside diameter	ø44.0 (1.7323)	ø44.12 (1.7370)
	Crankshaft journal outside diameter	ø44.0 (1.7323)	ø43.90 (1.7283)
	Oil clearance	0.036 ~ 0.092 (0.0014 ~ 0.0036)	0.15 (0.0059)

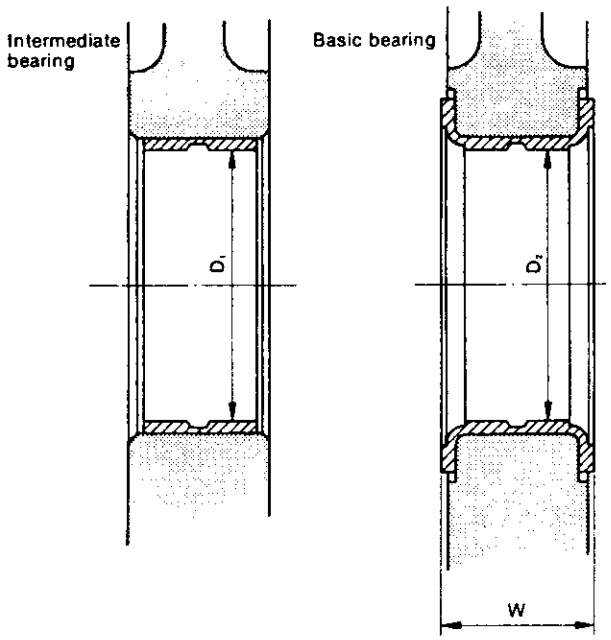
6-5.3 Inspecting the intermediate main bearing

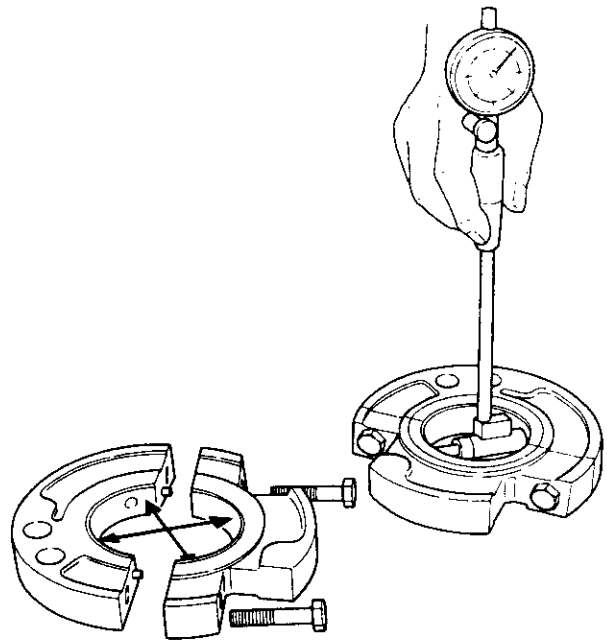
(1) Caution when inspecting
The intermediate main bearing is divided into two semicircles. Therefore, always measure after tightening the intermediate main bearing with the standard tightening torque. Measure at four places as in the main bearing, and replace it if it exceeds the wear limit.

kgf-m (ft-lb)

Tightening torque of the intermediate main bearing housing tightening bolt	3.0 ~ 3.5 (21.7 ~ 25.3)

(2) Intermediate main bearing
The intermediate main bearing on the flywheel side is the primary main bearing. Because this is a flange type bearing, measure the flange width as well as the inside diameter. When the flange wears away the side gap of the crankshaft increases.





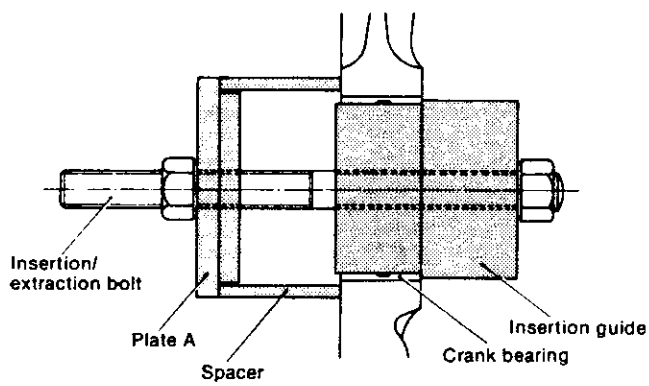
mm (in.)

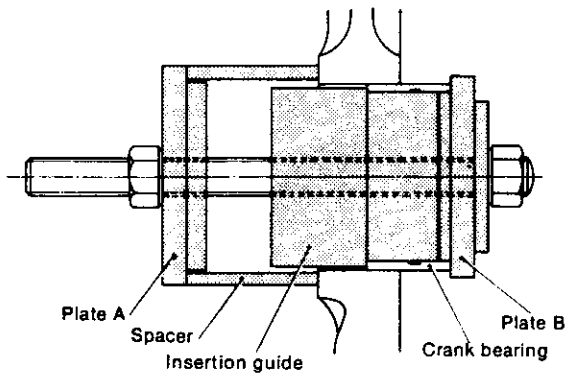
		Maintenance standard	Wear limit
Gear case side intermediate bearing inside diameter	D_1	ø44.0 (1.7323)	ø44.12 (1.7370)
Flywheel side intermediate bearing inside diameter	D_2	ø44.0 (1.7323)	ø44.12 (1.7370)
Width of intermediate bearing (Flywheel side)	W	$25^{-0.09}_{-0.17}$ (0.9776 ~ 0.9807)	24.63 (0.9697)

NOTE: Only at the flywheel end for model 1GM

6-5.4 Replacing the crank bearing

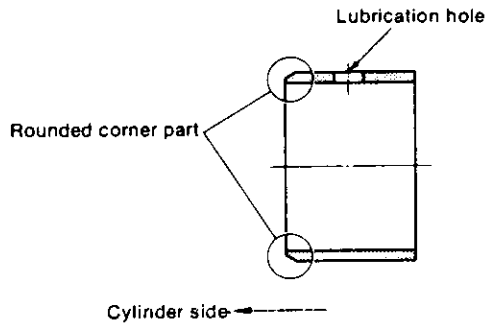
Since the crank bearings at both ends of the crankshaft are attached to the cylinder block and bearing housing with a press, a force of approximately 1.0 ~ 1.5 tons (2200 ~ 3300 lbs.) is required to remove them.
Moreover, since the crankshaft will not rotate smoothly and other trouble may occur if the bearing is distorted, it must always be installed with the special tool.
(1) Removal
Assemble the spacer and plate A as shown in the figure, place the puller/extractor against the bearing from the opposite end and pull the bearing by tightening the nut of the special tool. Remove the oil seal before pulling the bearing pressed to the bearing housing.
(2) Installation
Coat the outside of the bearing with oil and align the positions of the bearing oil holes. Then press in plate B





until it touches the cylinder block or bearing housing, using the puller/extractor as a guide, as shown in the figure.
After inserting the bearing, measure its outside diameter. If the bearing is distorted, remove it again and replace it with a new bearing.

(3) Crank bearing installation precautions

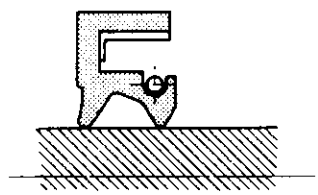


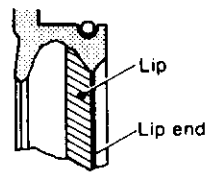
1) Pay careful attention to the crank bearing insertion direction. Insert the bearing so that the side with the outside fillet is on the outside.
2) Align the oil hole of the crank bearing with the oil holes of the cylinder block and bearing housing.
3) After inserting the crank bearing, check that the crankshaft rotates easily with the thrust metal and bearing housing installed.
4) Be careful that the bearing is not tilted during insertion.

6-6 Crankshaft oil seal

6-6.1 Oil seal type and size

Spiral oil seals are employed at both ends of the crankshaft. This type of oil seal is pulled toward the oil pan by pump action while the engine is running so that there is no oil leakage.
Since the viscous pump action will be lost if the lip of the seal is coated with grease, coat the lip with oil when assembling.

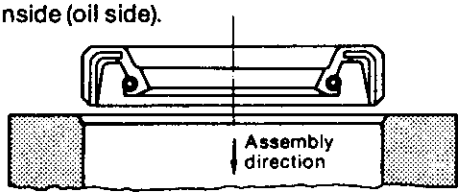




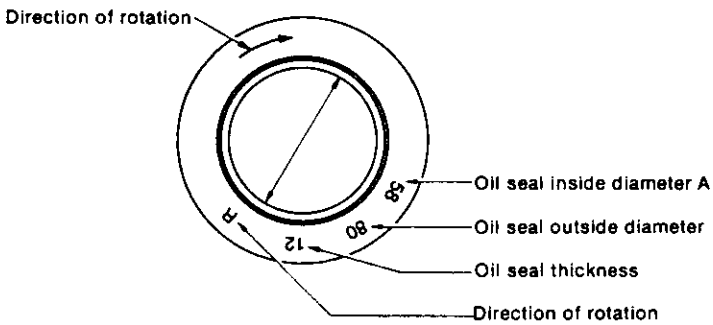
	Size	Spiral	Part No. (Yanmar)
For Main bearing metal housing	60829	Yes	124085-02220
For gear case	25408	Yes	121450-01800

6-6.2 Oil seal insertion precautions

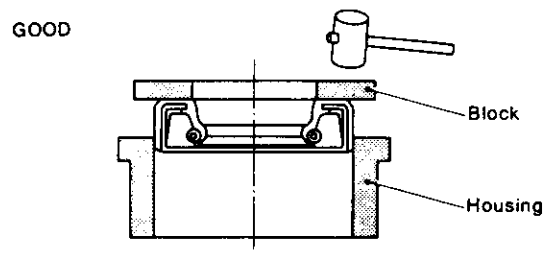
(1) Clean the inside of the housing hole, ascertaining that the hole was not dented when the seal was removed.
(2) Be sure that the insertion direction of the oil seal is correct. Insert so that the main lip mounting the spring is on the inside (oil side).

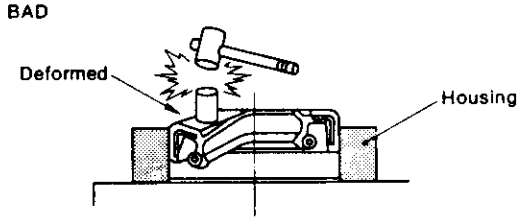


(3) Since the direction of rotation of the shaft is specified on a spiral oil seal, be sure that the rotating direction is correct.



(4) Insert the oil seal with a press. However, when unavoidable, the seal may be installed by tapping the entire periphery of the seal with a hammer, using a block. In this case, be careful that the oil seal is not tilted. Never tap the oil seal directly.





7. Flywheel and Housing

The function of the flywheel is, through inertia, to rotate the crankshaft in a uniform and smooth manner by absorbing the turning force created during the combustion stroke of the engine, and by compensating for the decrease in turning force during the other strokes.
The flywheel is mounted and secured by 5 bolts on the crankshaft end at the opposite end to the gear case; it is covered by the mounting flange (flywheel housing) which is bolted to the cylinder block.
On the crankshaft side of the flywheel is the fitting surface for the damper disc, through which the rotation of the crankshaft is transmitted to the input shaft of the reduction and reversing gear. The reduction and reversing gear is fitted to the mounting flange.
The flywheels imbalanced force on the shaft center must be kept below the specified value for the crankshaft as the flywheel rotates with the crankshaft at high speed. To achieve this, the balanced amount is adjusted by drilling holes in the side of the flywheel, and the unbalanced moment is adjusted by drilling holes in the circumference.

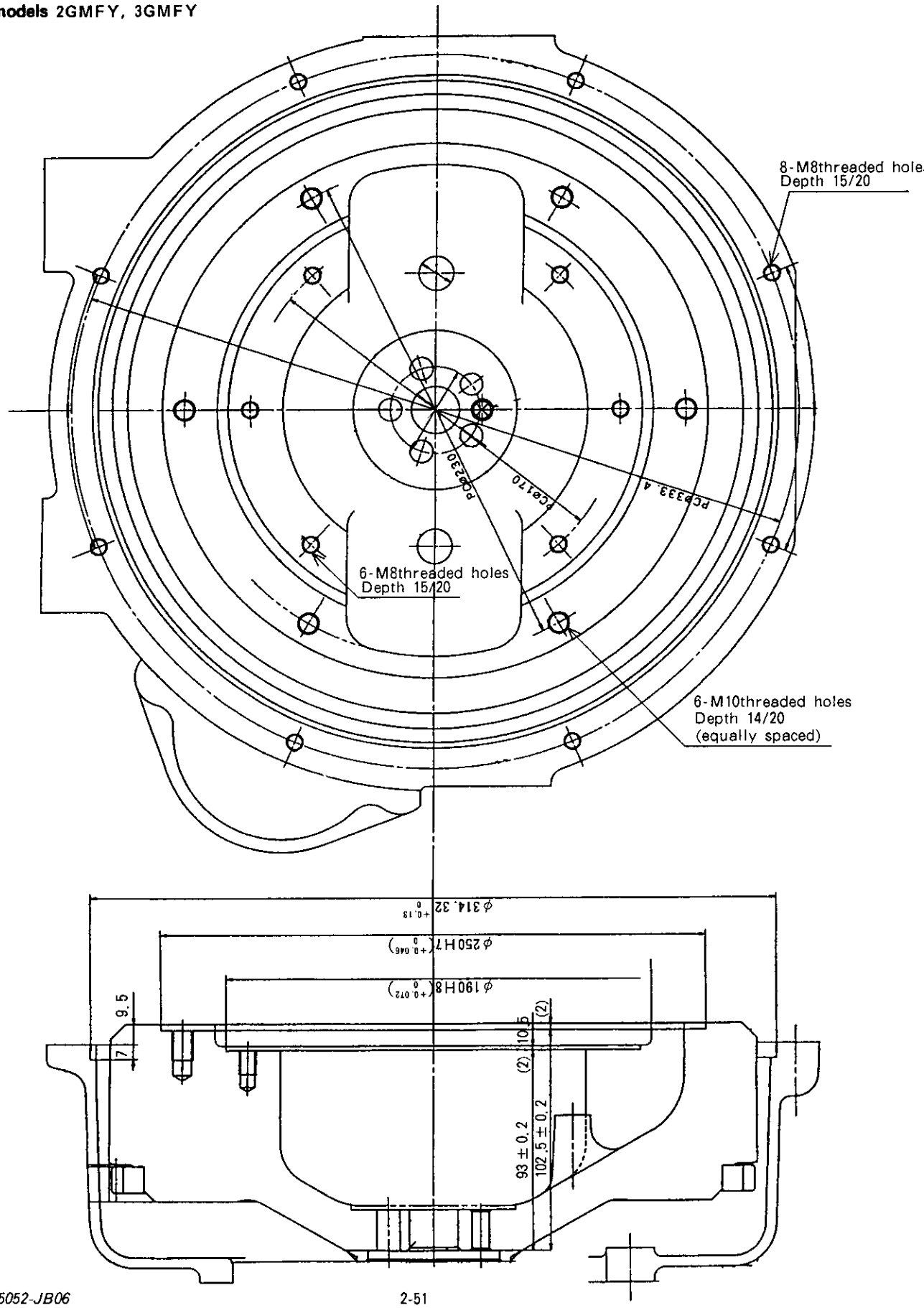
The ring gear is shrink fitted onto the circumference of the flywheel, and this ring gear serves to start the engine by meshing with the starter motor pinion.
The stamped letter and line which show top dead center of each cylinder are positioned either on the flywheel at the crankshaft side or at the side of the reduction and reversing gear, and by matching these marks with the arrow mark at the setting hole of the starter motor or at the hole of the flywheel housing, the rotary position of the crankshaft can be ascertained in order to adjust tappet clearance or fuel injection timing.

7-1 Specifications of flywheel

			2GMFY	3GMFY	
Outside diameter of flywheel		mm	$\phi 252_{-0.2}^{0}$		
Width of flywheel		mm	53	70	
Weight of flywheel (including ring gear)		kg	12.6	17.5	
GD² value		kgf-m²	0.5	0.70	
Circumferential speed		m/s	47.5 (3600 rpm)		
Speed fluctuation rate		δ	1/74 (3600 rpm)	1/116 (3600 rpm)	
Allowable amount of imbalance		gf-cm	25	30	
Allowable moment of imbalance		gf-cm	244 ±20	363 ±20	
Fixing part of damper disc	Pitch circle diameter of bolts	mm	150		
	No. of bolts × bolt diameter		6-M8 thread equally spaced		
Fixing part of crankshaft	Pitch circle diameter of bolts	mm	41		
	No. of thread holes	mm	5-M10		
	Fit joint diameter		ø60M7		
Model of reduction and reversing gear			Y-5M	Y-5M	YX-6
Mounting flange No.			SAE No. 6 (in metric unit)		
Ring gear	Center diameter	mm	246.38		
	No. of teeth		Z = 97		

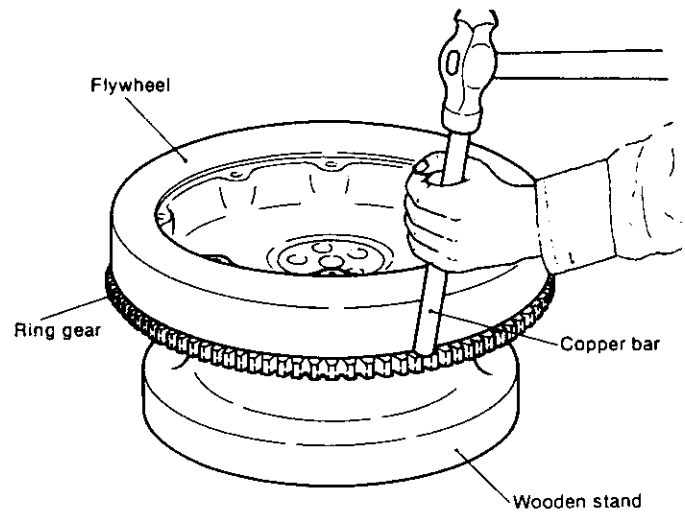
7-2 Dimensions of flywheel and mounting flange

7-2.1 For models 2GMFY, 3GMFY



7-3 Ring gear

When replacing the ring gear due to excessive wear or damaged teeth, heat the ring gear evenly at its circumference, and after it has expanded drive it gradually off the flywheel by tapping it with a hammer a copper bar or something similar around the whole circumference.

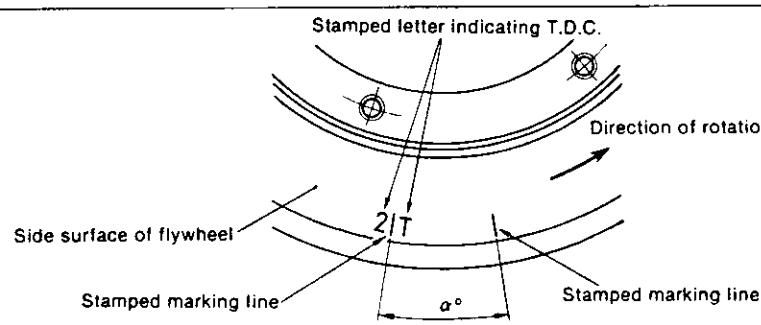


mm (in.)

Interference of ring gear	0.188 ~ 0.348 (0.0074 ~ 0.0137)

7-4 Position of top dead center

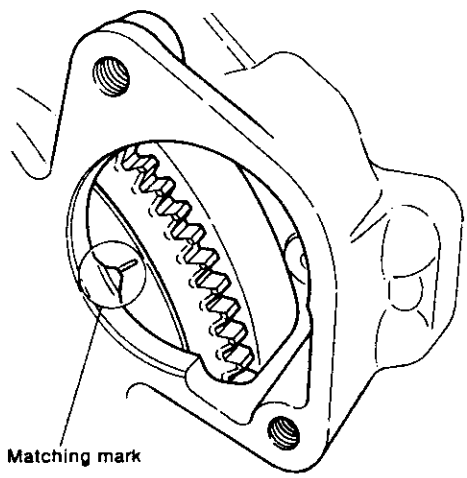
(1) Marking



	2GMFY	3GMFY
Stamped letter	1T, 2T	1T, 2T, 3T
Angle α of Stamped lines	15°	18°
Stamped surfaced	Both surfaces	Both surfaces

(2) Matching mark

The matching mark is made at the setting hole of the starter motor on all models.



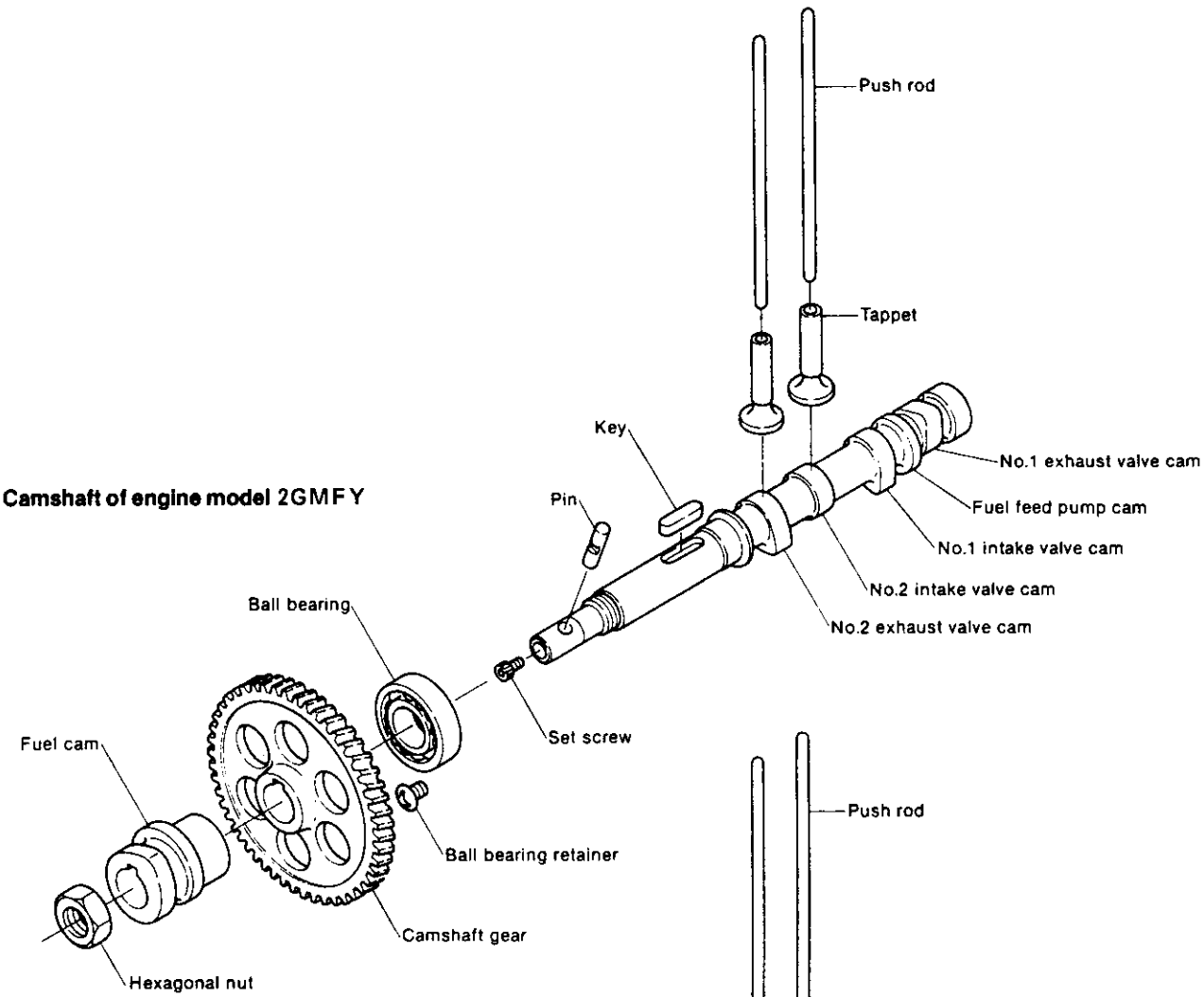
8. Camshaft

8-1 Construction of the camshaft

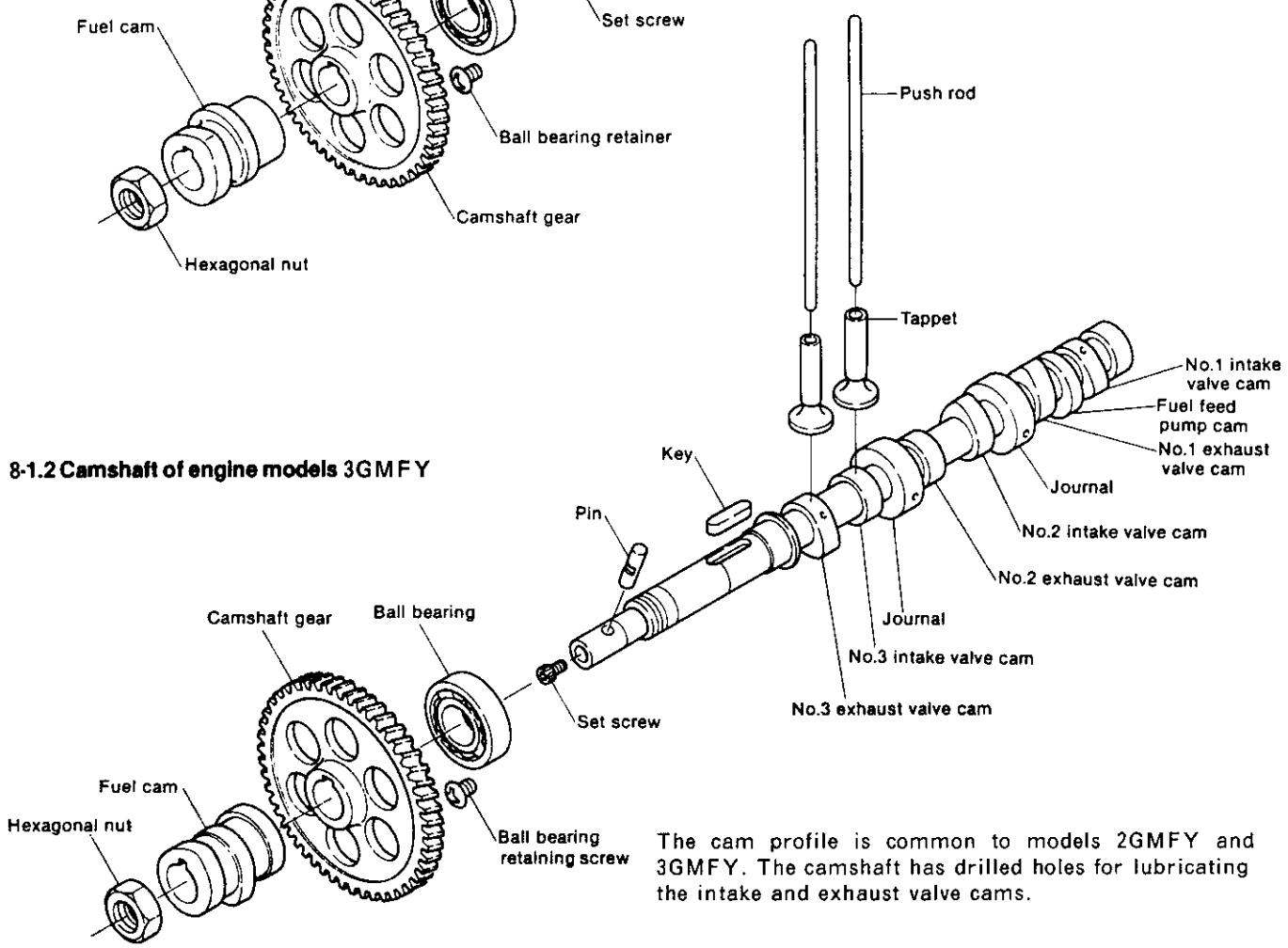
The camshaft, an integral camshaft with intake and exhaust cams, is driven by the camshaft gear and may be timed individually.
On top of the intake and exhaust cams a tappet is mounted guided by the cylinder block. The tappet moves up and down with the rotation of the cam and opens and closes the intake and exhaust valves with the pushrod and rocker arm.
During high speed operation the cam surface is exposed to a strong force of inertia from moving valves and spring load, and comes in to contact with the tappet at high surface pressure. Therefore, to reduce wear the surface is tempered by high frequency hardening, as well as a cam form selected to decrease the force of inertia. Since the intake and exhaust cam profile of this engine is a parabolic acceleration cam with a buffering curve, movement of the valve at high speed is smooth, improving the durability of the intake and exhaust valve seats.

The camshaft on models 2GMFY does not have an intermediate bearing, however, the camshaft on models 3GMFY is supported by two intermediate bearings in order to avoid deflection of the camshaft.
The fuel cam is separated from the camshaft in all engine models and it is inserted into the camshaft together with the camshaft gear by matching the key and slot and is fixed by an end nut.
The cam for the fuel feed pump is integrated with the camshaft and it is machine finished. The cam is located between the intake and exhaust valve cams of No.1 cylinder at the flywheel end in all engine models.

8-1.1 Camshaft of engine model 2GMFY

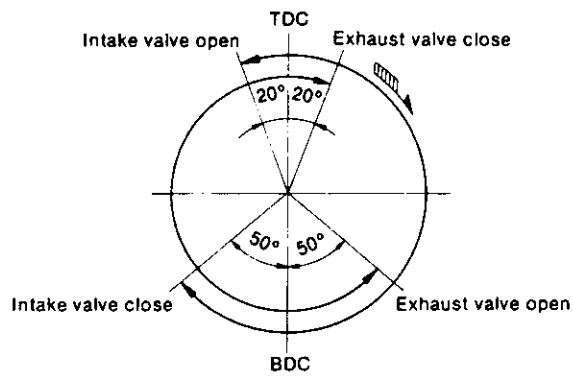


8-1.2 Camshaft of engine models 3GMFY



The cam profile is common to models 2GMFY and 3GMFY. The camshaft has drilled holes for lubricating the intake and exhaust valve cams.

8-2 Valve timing diagram

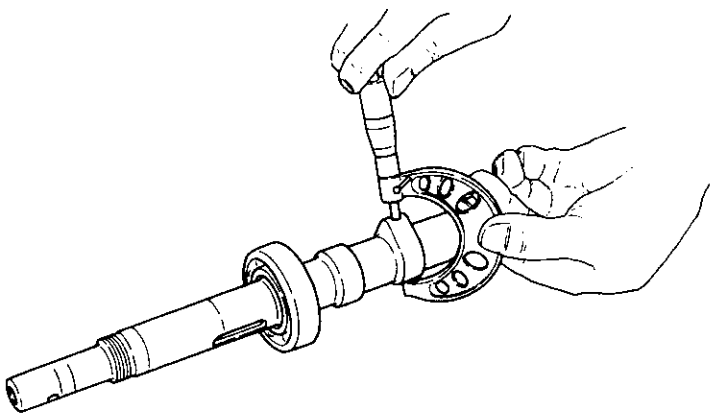


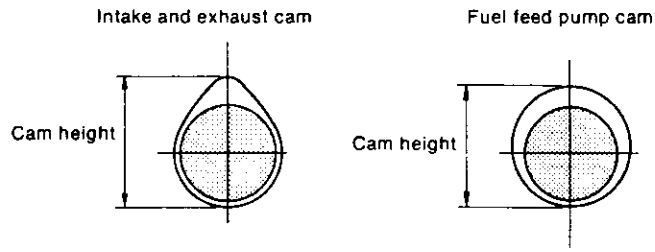
Intake and exhaust valve head clearance	0.2mm (0.0079in.)
Intake valve open b. TDC	20°
Intake valve close a. BDC	50°
Exhaust valve open b. BDC	50°
Exhaust valve close a. TDC	20°

8-3 Inspection

Visually check for steps or wear on the cam surface and replace if excessive.
Since the cam surface is tempered and ground, there is almost no wear. However, measure the height of the intake and exhaust cams, and replace the camshaft when the measured value exceeds the wear limit.

8-3.1 Camshaft height





mm (in.)

	Maintenance standard	Wear limit
Intake and exhaust cam	35 (1.3780)	34.70 (1.3661)
Fuel feed pump cam	33 (1.2992)	—

8-3.2 Journals of camshaft

Measure the amount of wear and eccentricity of the camshaft journal. Measurements must be carried out in at least two directions for each position.
Replace the camshaft with a new one if the value exceeds the allowable limit.

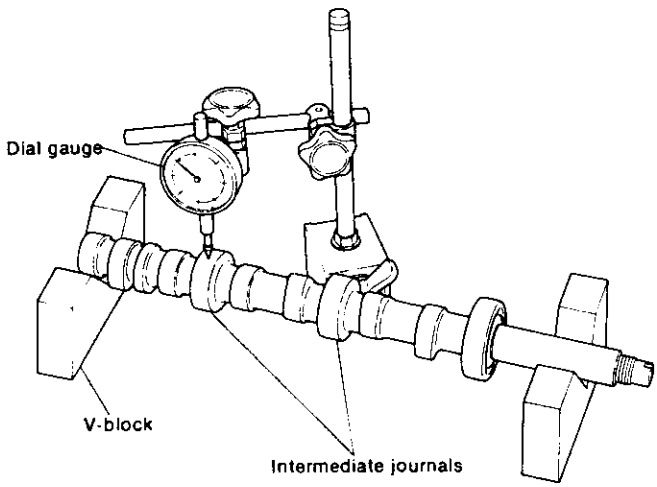
mm (in.)

	Maintenance standard	Clearance at assembly	Maximum allowable clearance
Flywheel side	ø30 (1.1811)	0.050 ~ 0.100 (0.0020 ~ 0.0039)	0.15 (0.0059)
Center	ø41.5 (1.6339)	0.050 ~ 0.100 (0.0020 ~ 0.0039)	0.15 (0.0059)

8-3.3 Camshaft deflection (models 3GMFY)

Support the camshaft at both ends on V-blocks, and measure the concentricity of the intermediate journal with a dial gauge. If the camshaft is excessively bent, replace it.

NOTE: Indicated valve on the dial gauge is the amount of swing, and the amount of bend is half the reading given.



mm (in.)

		Maintenance standard	Wear limit
Camshaft deflection	3GMFY	—	0.02 (0.0008)

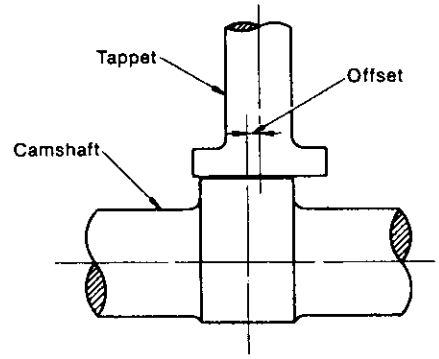
8-4 Camshaft ball bearing

The camshaft bearing is a single row deep groove ball bearing. The construction and material of this ball bearing is such that it can withstand the radial load, thrust loads in both directions, and a combination of both these loads. When the ball bearing does not rotate smoothly, or when the axial direction play is large, replace the bearing.

Ball bearing type : 6205

8-5 Tappets

These mushroom type tappets feature a special iron casting with chill-hardened contact surfaces for high wear resistance. The center of the cam surface width and the center of the tappet are offset to prevent eccentric wear of the contact surface.

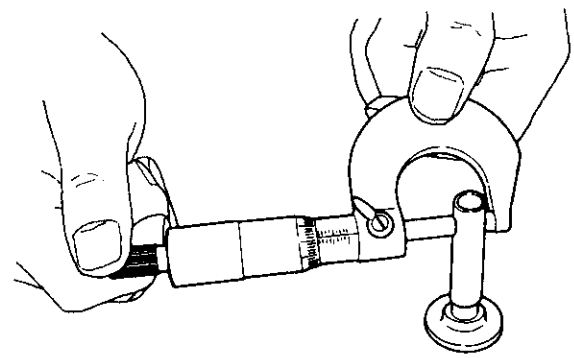


8-5.1 Tappet disassembly precautions

The cylinder number and intake and exhaust must be clearly indicated when disassembling the camshaft and tappets.

8-5.2 Tappet stem wear and contact

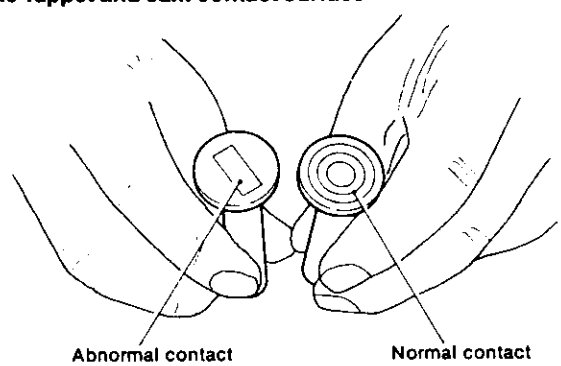
Measure the outside diameter of the tappet stem, and replace the tappet when the wear limit is exceeded or contact is uneven.



mm (in.)

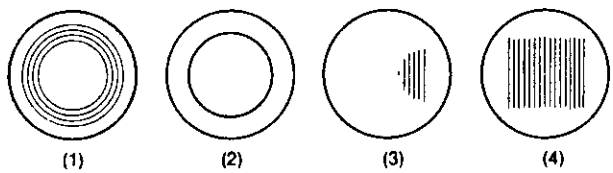
	Maintenance standard	Wear limit
Tappet stem outside diameter	ø10.0 (0.3937)	ø9.95 (0.3917)
Tappet stem and guide hole clearance	0.010~0.040 (0.0004~0.0016)	0.10 (0.0039)

8-5.3 Tappet and cam contact surface

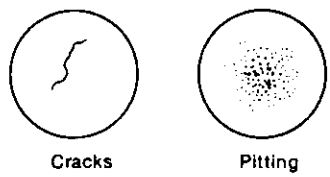


Since the tappet and cam are offset, the tappet rotates in an up and down movement during operation, so there is no uneven contact.
Since eccentric wear will occur if cam tappet contact is poor, replace the tappet if there is any uneven contact or deformation.

Contact surface conditions are shown in the following:



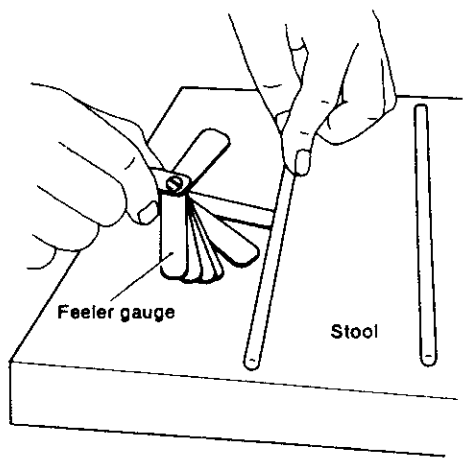
(1), (2) Traces when the tappet is rotating normally.
(3), (4) Traces when the tappet does not rotate and the contact surface remains still and only the point of contact wears away excessively. Discover the reason for the lack or rotation and replace the tappet.



Also, there may be perforated pittings or cracks on the contact surface of the tappet. In such cases, discover the reason for abnormality and replace the tappet.

8-6 Push rods

The push rods are sufficiently rigid and strong to prevent bending.
Place the push rod on a stool or flat surface and measure the clearance between the center of the push rod and the flat surface, and replace the push rod if the wear limit is exceeded.



Check both ends for wear and peeling, and replace the push rod if faulty.

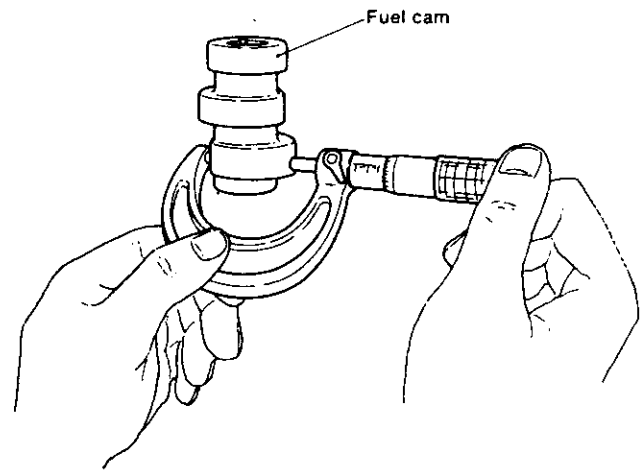
mm (in.)

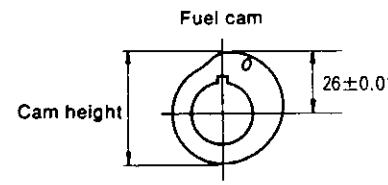
	Maintenance standard	Wear limit
Push rod bend	0.03 or less (0.00118 or less)	0.3 (0.0118)
Push rod length	136 (5.3543)	—

8-7 Fuel cam

8-7.1 Fuel cam check

The fuel cam is separate from the intake and exhaust valve cams and is secured to the camshaft together with the camshaft gear by a key. The cam drives the fuel pump.
The fuel cam like the intake and exhaust valve cams is ground-finished after being quenched. Therefore, it is almost free from wear. However, if step or eccentric wear is found to be excessive, replace the cam.



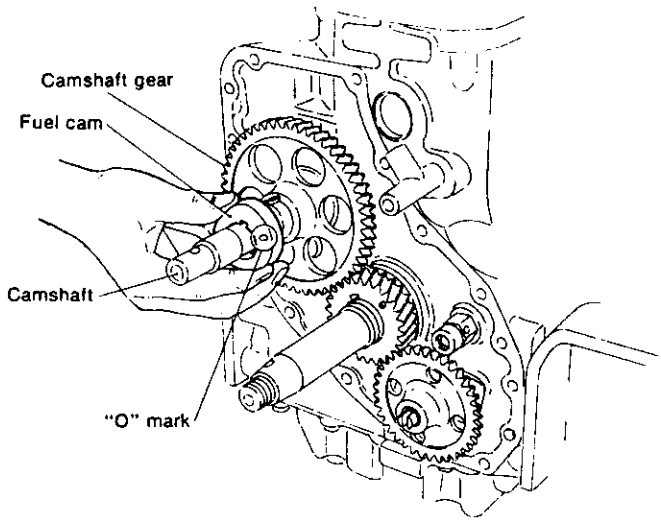


mm (in.)

	Maintenance standard	Wear limit
Fuel cam height	45 (1.7717)	44.90 (1.7677)

8-7.2 Fuel cam assembly precautions

Install the fuel cam by aligning it with the key of the camshaft. If the installation direction is not correct, the fuel injection timing will be considerably off and the engine will not start.
When assembling the fuel cam, be sure that the "0" mark side of the cam is opposite the camshaft gear.

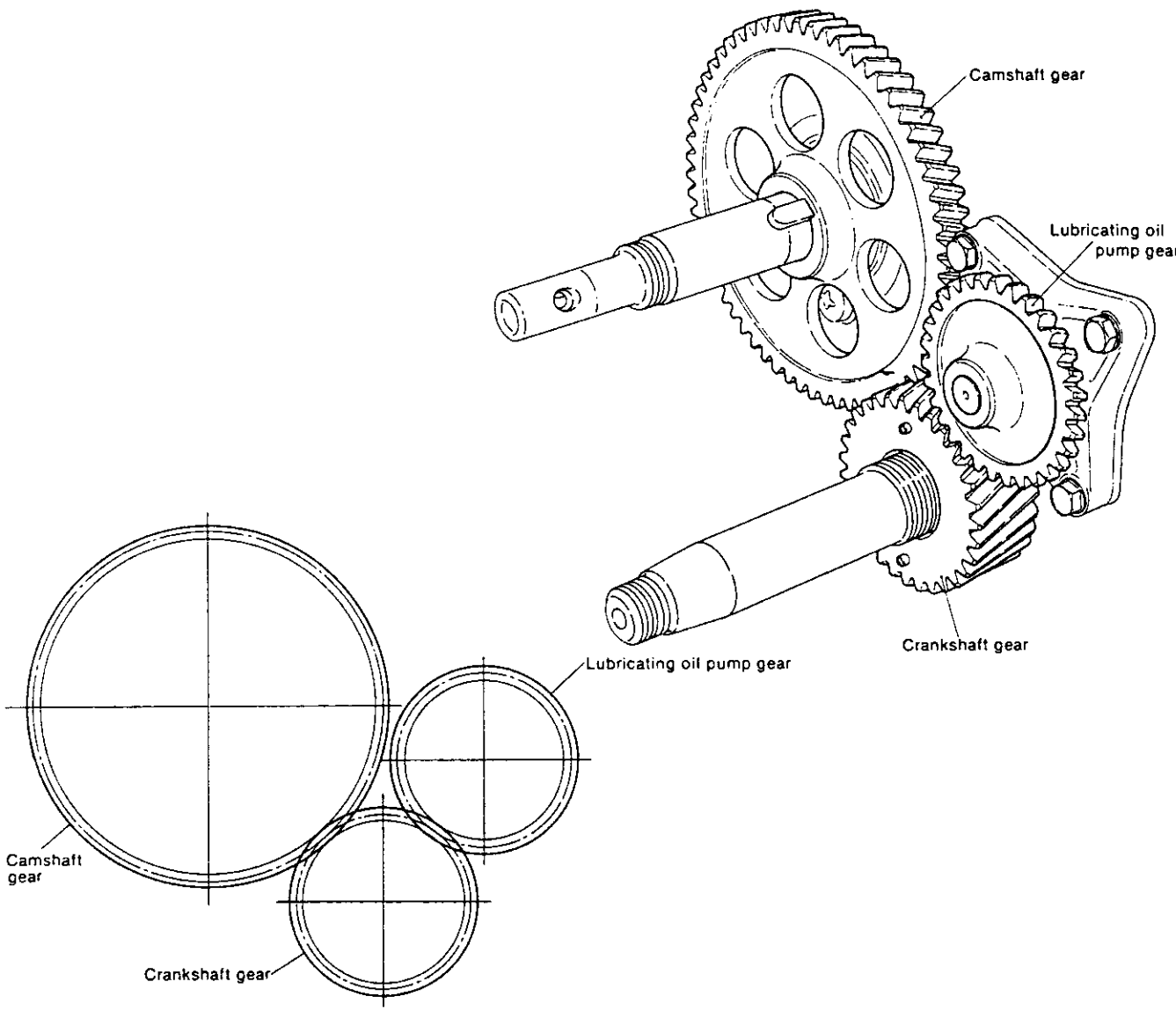

Camshaft gear
Fuel cam
Camshaft
"O" mark

9. Timing Gear

9-1 Timing gear train construction

The camshaft, which is the basic component of the valve opening and closing mechanism, and the fuel cam, which determines the fuel injction timing, are driven by the timing gear.
The timing gear consists of the crankshaft gear and the camshaft gear.

The crankshaft gear also drives the governor weight and the lubricating oil pump by meshing with the lubricating oil pump gear.
For the timing gears, helical gears are used.
The timing gear case, which covers these gears, is fitted to the cylinder body with bolts.



	Module (m)	Tooth profile	No. of teeth	Center distance
Camshaft gear	2.0	Full depth	62	$99^{+0.048}_{0}$mm (3.8976 ~ 3.8995in.)
Crankshaft gear	2.0	Full depth	31	$65.98^{+0.046}_{0}$mm (2.5976 ~ 2.5995in.)
Lubricating oil pump gear	2.0	Full depth	31	

9-2 Disassembly and reassembly of the timing gear

9-2.1 Disassembly

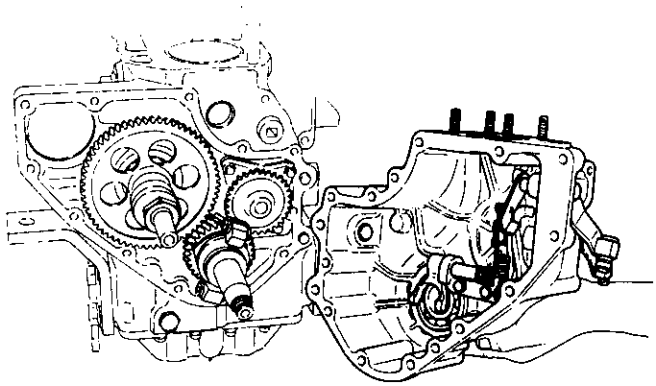
(1) Remove the alternator.
(2) Remove the rubber hose by loosening the hose clip on the cooling water pump.

NOTE: The cooling water pumpt does not need to be removed. Difficult to connect it with the rotor shaft of the lubricating oil pump if the gear case has not been previously assembled.

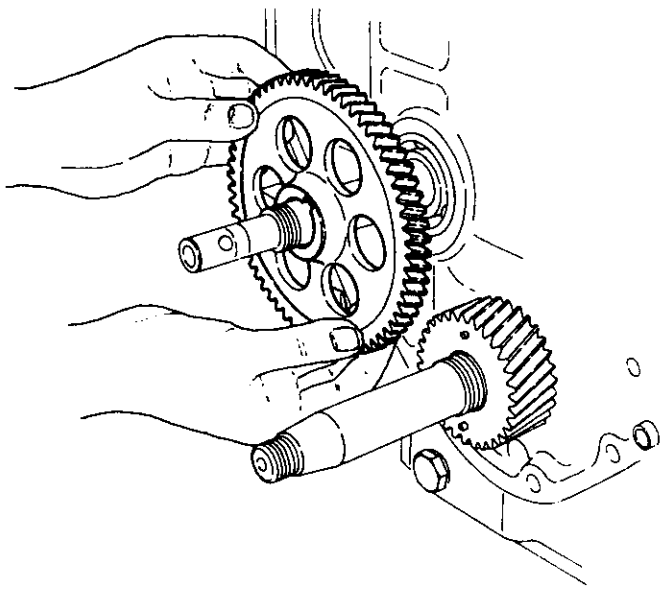
(3) Remove the crankshaft V-pulley.
(4) Remove the fuel injection pump

NOTE: Remove the cap at the timing gear case end, and remove the fuel injection pump by moving the governor second lever while observing through the hole.

(5) Loosen the hexagonal bolt with the hole, and remove the straight pin from the manual starting handle.
(6) Remove the gear case.



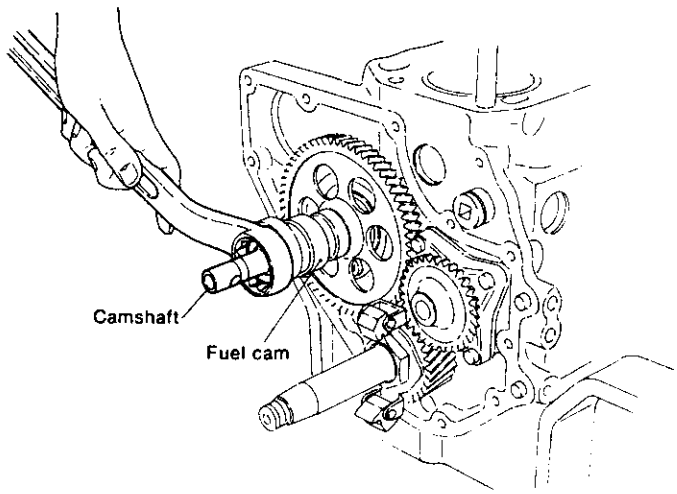
(7) Remove the governor sleeve and needle bearing collar.
(8) Loosen the hexagonal nut, and remove the governor weight support.
(9) Remove the camshaft nut, and take out the fuel cam.
(10) Remove the camshaft gear, crankshaft gear and lubricating oil pump.



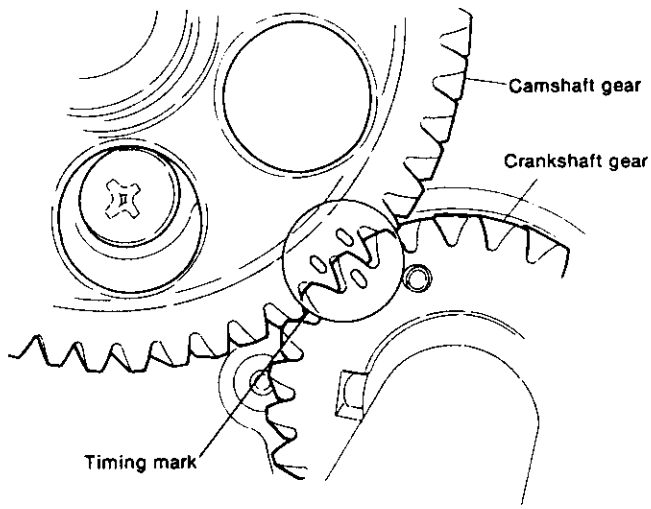
9-2.2 Disassembly and reassembly precautions

Reassemble in the reverse order of disassembly.
Pay attention to the following points when assembling.

(1) Timing mark
A timing mark is provided on the crankshaft gear and camshaft gear to adjust the timing between opening and closing of the intake and exhaust valves and fuel injection when the piston is operated.
Always check that these timing marks are aligned when disassembling and reassembling the timing gear.
First, fit the crankshaft gear to the crankshaft by matching the key and slot. Next, by rotating the camshaft fit the camshaft gear in the position where the marks on the camshaft gear and the crankshaft gear align.



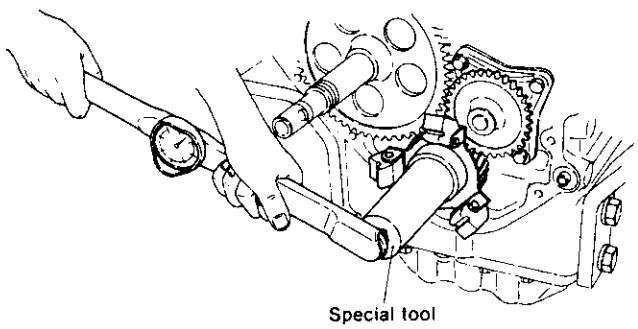
(2) Fuel cam
When the fuel cam is fitted to the camshaft, assemble it keeping the surface marked 'O' towards the front.
(Refer to 2-57)
(3) Tightening torque of nut



kgf-m (ft-lb)

Camshaft end nut	7.0 ~ 8.0 (50.6 ~ 57.9)
Crankshaft nut	8.0 ~ 10.0 (57.9 ~ 72.3)

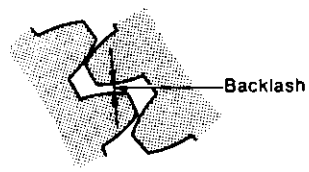
NOTE: When tightening or loosening the crankshaft nut, take care that the spanner does not touch the governor weight or weight support.



9-3 Inspection

9-3.1 Backlash

Unsuitable backlash will cause excessive wear or damage at the tooth top and abnormal noise during operation. Moreover, in extreme cases, the valve and fuel injection timing will deviate and the engine will not run smoothly. When the backlash exceeds the wear limit, repair or relace the gears as a set.

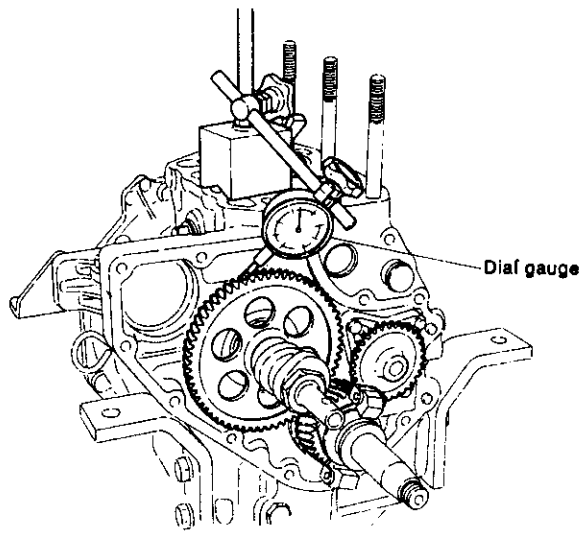


mm (in.)

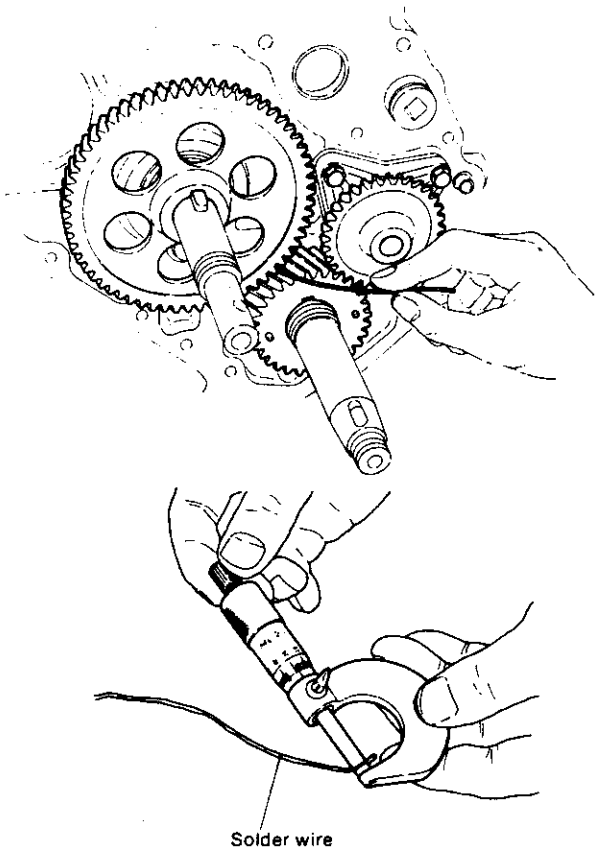
	Maintenance standard	Wear limit
Crankshaft gear and camshaft gear backlash	0.05 ~ 0.13 (0.0020 ~ 0.0051)	0.3 (0.0118)
Crankshaft gear and lubricating oil pump driven gear backlash	0.05 ~ 0.13 (0.0020 ~ 0.0051)	0.3 (0.0118)

Measuring backlash

(1) Lock one of the two gears to be measured and measure the amount of movement of the other gear by placing a dial gauge on the tooth surface.

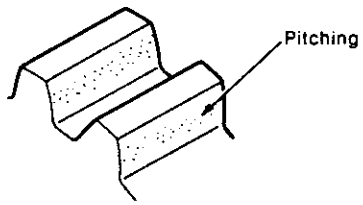


(2) Insert a piece of quality solder between the gears to be measured and turn the gears. The backlash can be measured by measuring the thickness of the crushed part of the solder.



9-3.2 Inspecting the gear tooth surface

Check the tooth surface for damage caused by pitching and check tooth contact. Repair if the damage is light. Also inspect the gears for cracking and corrosion.
When gear noise becomes high because of wear or damage, replace the gears as a set.



9-3.3 Inspecting the gear boss

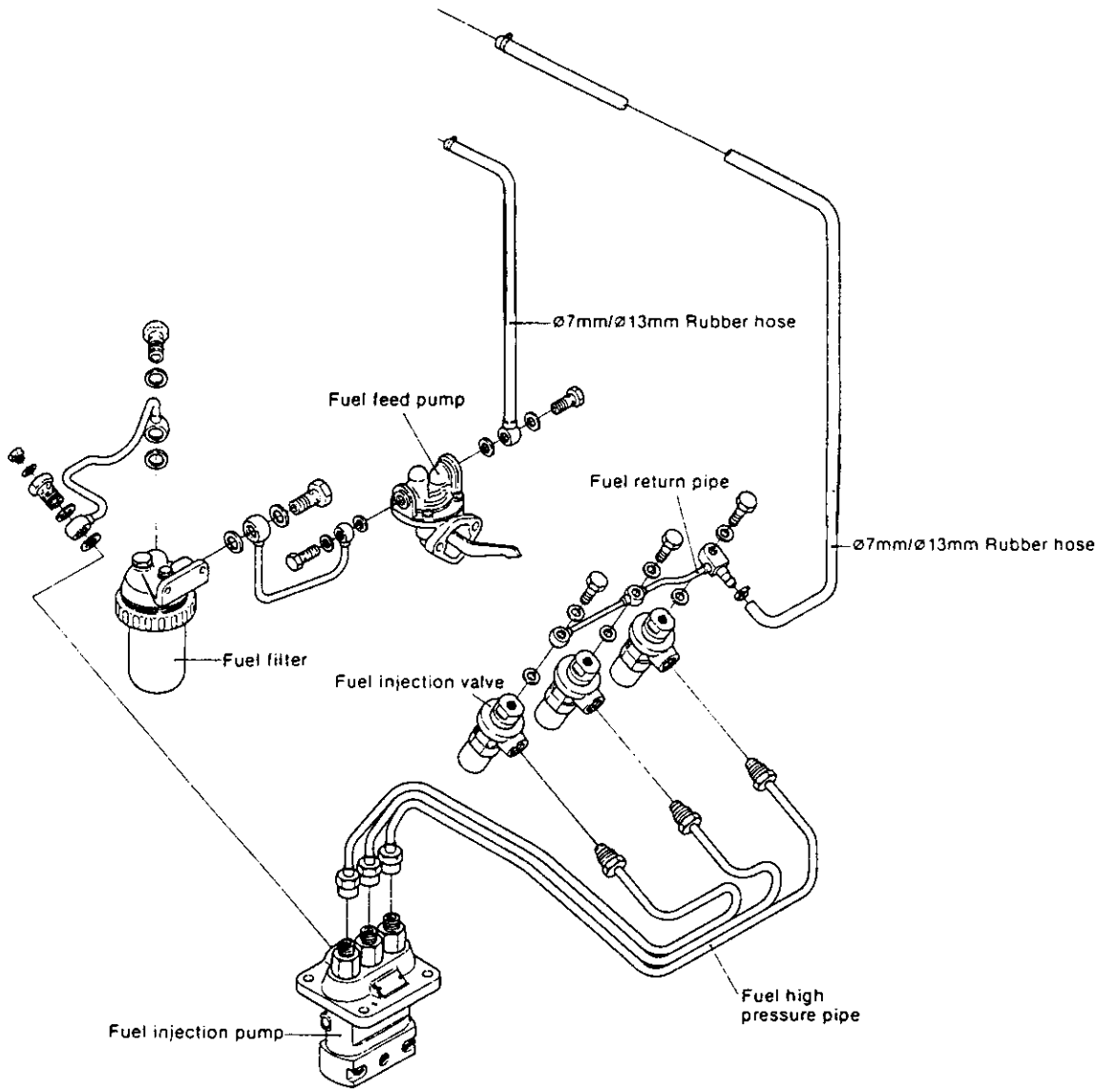
Check for play between each gear and the gear shaft, burning caused by play, key damage, and for cracking at the edge of the key groove. Replace the gears when faulty.

CHAPTER 3

FUEL SYSTEM

1. Fuel Injection System 3-1
2. Injection Pump. 3-3
3. Injection Nozzle 3-22
4. Fuel Filter. 3-26
5. Fuel Feed Pump. 3-27

1. Fuel Injection System



1-1 Construction

The fuel system consists mainly of an injection pump, injection pipe, and an injection nozzle, plus a fuel tank, feed pump, fuel filter and other associated parts. The injection pump is driven by a fuel cam mounted on the camshaft and is controlled by a governor. Fuel stored in the fuel tank is fed to the fuel filter through the feed pump. (The feed pump is indispensable when the fuel tank is installed lower than the injection pump.)
Dirt and other impurities in the fuel are removed by the filter and the clean fuel is sent to the injection pump, which applies the necessary pressure for injection to the fuel and atomizes the fuel by passing it through the injection nozzle. The injection pump also controls the amount of fuel injected and the injection timing according to the engine load and speed by means of a governor.
The injection pump feeds the fuel to the injection nozzle through a high pressure pipe. The pressurized fuel is atomized and injected by the injection nozzle into the precombustion chamber.
Fuel that overflows the injection nozzle is returned to the fuel tank through the fuel return pipe. The quality of the equipment and parts comprising the fuel injection system directly affects combustion performance and has a considerable effect on engine performance. Therefore, this system must be inspected and serviced regularly to ensure top performance.

1-2 Fuel injection system specifications

	2GMFY	3GMFY
Type of injection pump	YPFR-0707-2	YPFR-0707
Type of injection nozzle	YDN-OSDYD1 (Throttle)	
Injection pressure	170 kgf/cm² (2418 lb/in.²)	
Plunger diameter × stroke	ø6mm (0.2362in.) × 7mm (0.2756in.)	
Delivery valve suction capacity	23.5mm³/st (0.0014in.³/st)	
Fuel feed pressure	0.1 kg/cm² (1.4224 lb/in.²)	

2. Injection Pump

The injection pump is the most important part of the fuel system. This pump feeds the proper amount of fuel to the engine at the proper time in accordance with the engine load.

This engine uses a Bosch integral type injection pump for two/three cylinders. It is designed and manufactured by Yanmar, and is ideal for the fuel system of this engine.

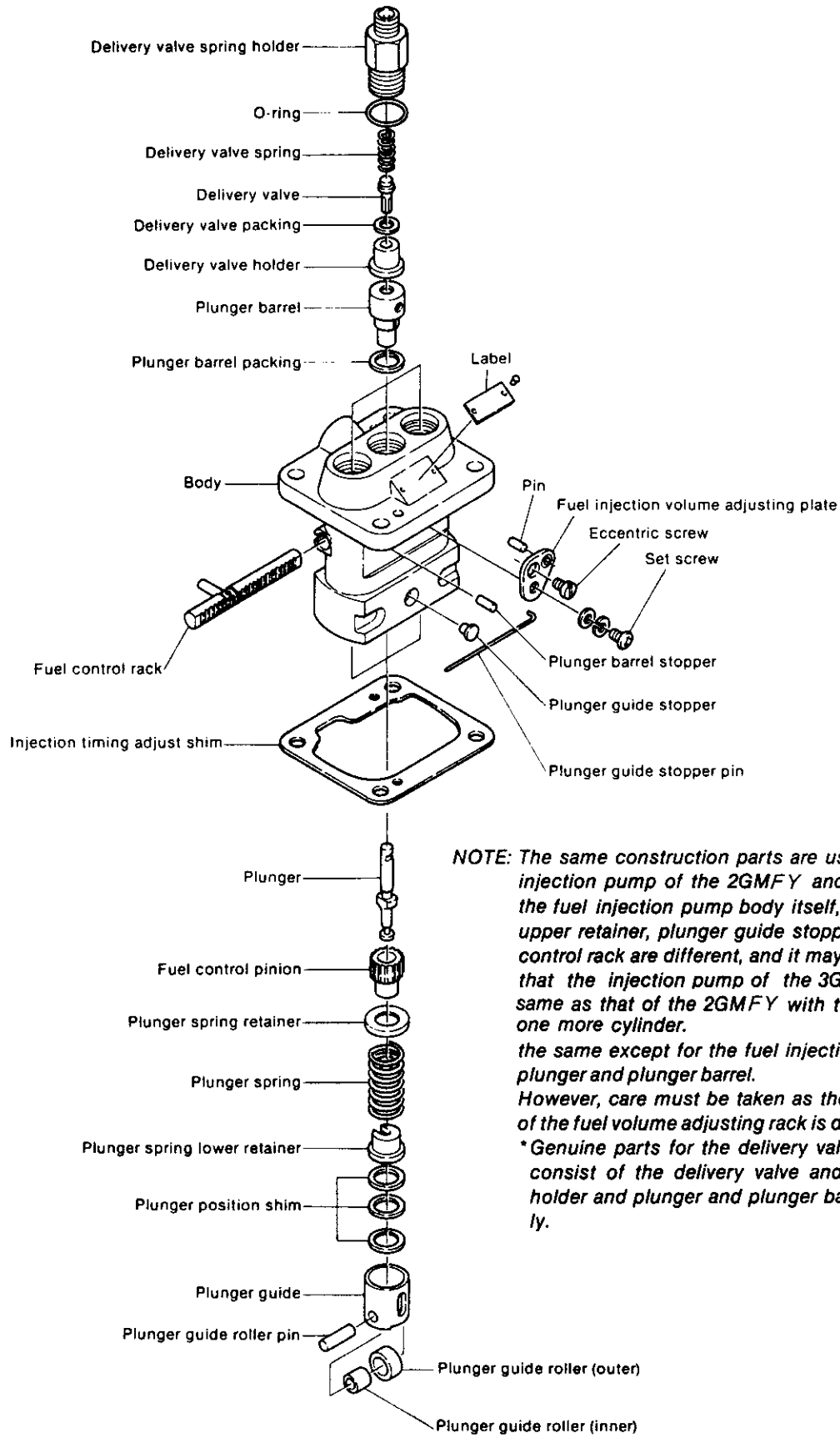
Since the injection pump is subjected to extremely high pressures and must be accurate as well as deformation—and wear-free, stringently selected materials are used and precision finished after undergoing heat treatment.

The injection pump must be handled carefully. Since the delivery valve and delivery valve holder and the plunger and plunger barrel are lapped, they must be changed as a pair.

The fuel injection pump is constructed from the following main parts.

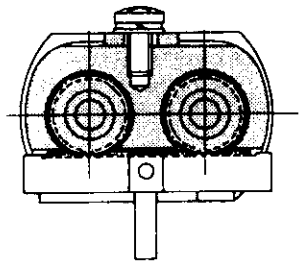
(1) Pump parts which compress and deliver the fuel: plunger, plunger barrel.
(2) Parts which move the plunger: camshaft, tappet, plunger spring, plunger spring retainer.
(3) Parts which control the injection amount: control rack, control pinion, control sleeve.
(4) Parts which prevent back flow and dripping during injection: delivery valve.

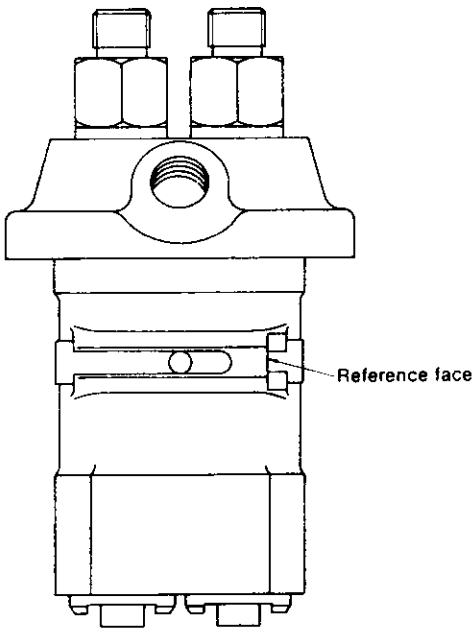
2-1 Construction



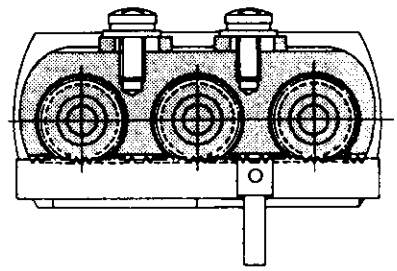
NOTE: The same construction parts are used for the fuel injection pump of the 2GMFY and 3GMFY. Only the fuel injection pump body itself, plunger spring upper retainer, plunger guide stopper pin and fuel control rack are different, and it may be understood that the injection pump of the 3GMFY is the same as that of the 2GMFY with the addition of one more cylinder.
the same except for the fuel injection pump body, plunger and plunger barrel.
However, care must be taken as the basic surface of the fuel volume adjusting rack is different.
**Genuine parts for the delivery valve and plunger consist of the delivery valve and delivery valve holder and plunger and plunger barrel respectively.*

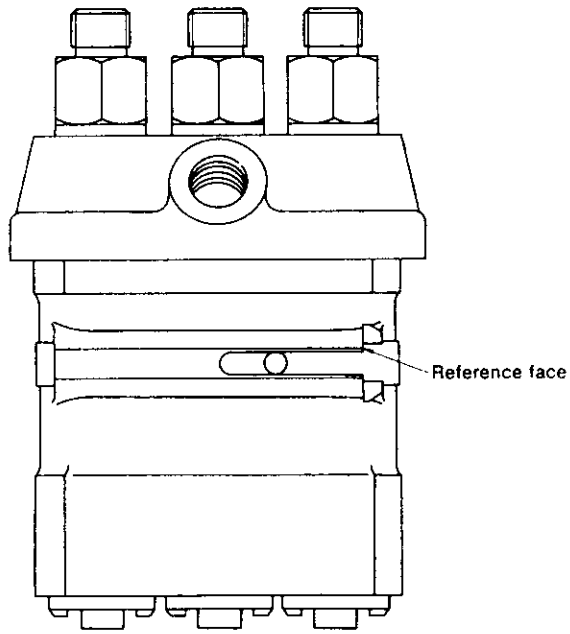
2GMFY

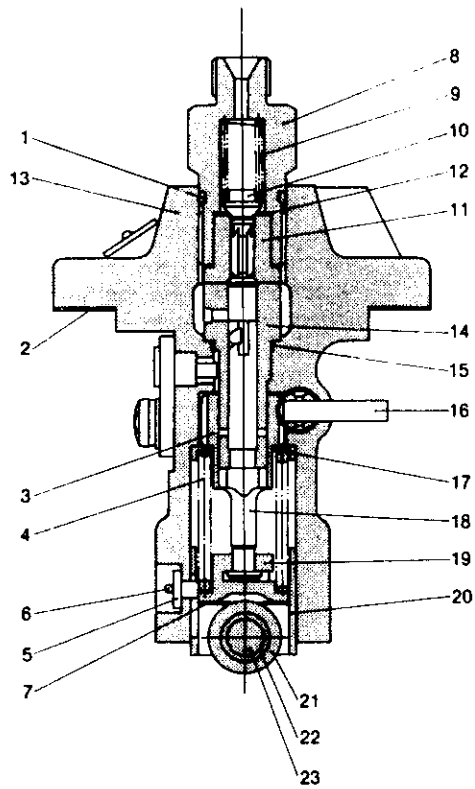




3GMFY







1 O-ring
2 Injection timing shim
3 Fuel control pinion
4 Plunger spring
5 Plunger guide stopper
6 Plunger guide stopper pin
7 Plunger position shim
8 Delivery valve spring holder
9 Delivery valve spring
10 Delivery valve
11 Delivery valve holder
12 Delivery valve packing
13 Body
14 Plunger barrel
15 Plunger barrel packing
16 Fuel control rack
17 Plunger spring retainer
18 Plunger
19 Plunger spring lower retainer
20 Plunger guide
21 Plunger guide roller (outer)
22 Plunger guide roller (inner)
23 Plunger guide roller pin

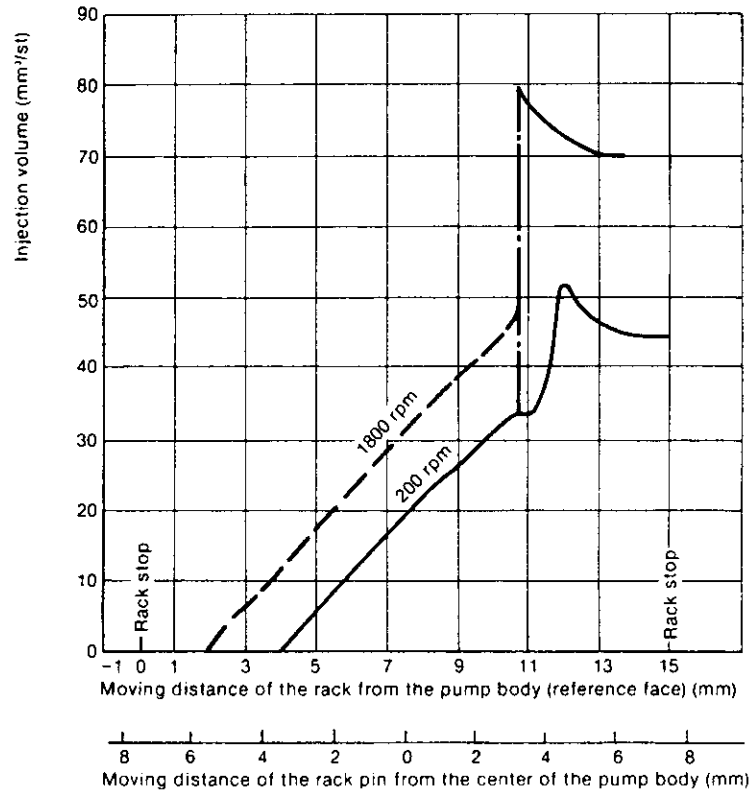
2-2 Specifications and performance of fuel injection pump

2-2.1 Specifications of fuel injection pump

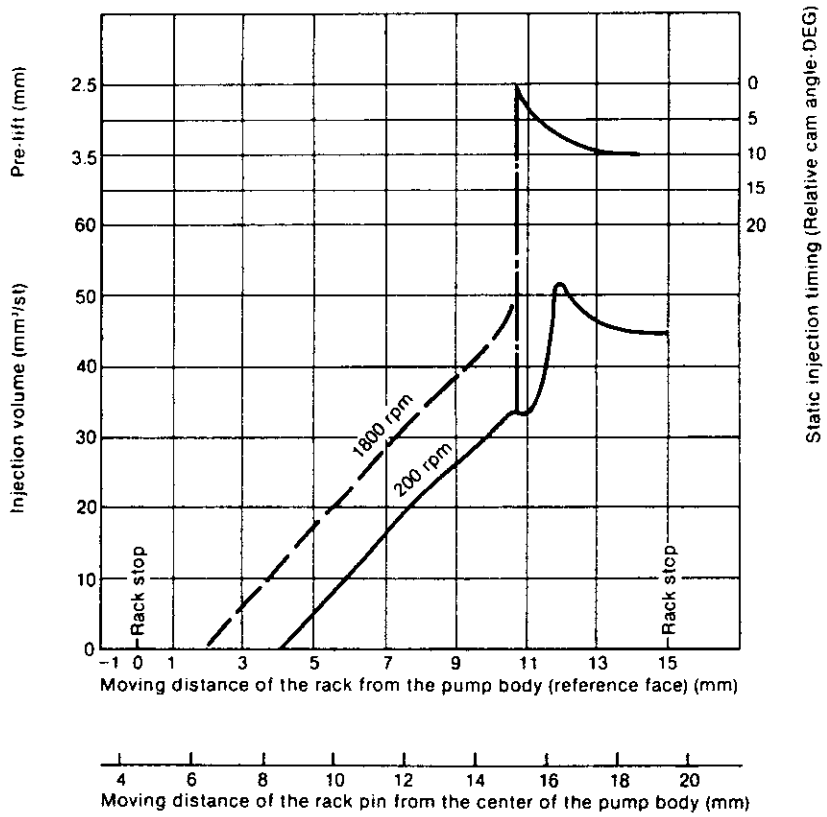
			2GMFY	3GMFY
Plunger diameter			6mm (0.2362in.)	
Standard plunger stroke			7mm (0.2756in.)	
Static mechanical lift at injection			2.5mm (0.0984in.) [at starting 3.2mm (0.1260in.)]	
Sliding resistance of fuel volume adjusting rack (when pump stops)			60g (0.002 lb) or less	
Top clearance of plunger (at the set dimension of 76 ±0.05mm)			1.0mm (0.0394in.)	
Thickness of plunger position adjusting shim			0.1mm (0.0039in.), 0.2mm (0.0079in.), 0.3mm (0.0118in.)	
Plunger spring (124950-51190 commonly used)	Free length		35.5mm (1.3976in.)	
	Spring constant		1.93 kgf/cm(10.8 lb/in.)	
	Load	At upper limit	25.1 kg (55.3 lb)	
		At lower limit	11.6 kg (25.6 lb)	
		At static injection	16.4 kg (36.2 lb)	
Suction volume of delivery valve			23.5mm³ (0.0014in.³)	
Opening pressure of delivery valve			Approx. 16.3 kgf/cm² (231.8 lb/in²)	
Delivery valve spring (124550-51320 commonly used)	Free length		21.0mm (0.8268in.)	
	Spring constant		0.64 kgf/cm(9.1 lb/in.)	
Rack stroke			Approx. 15mm (0.5906in.)	

2-2.2 Injection volume characteristics of fuel injection pump

(1) Model 2GMF Y

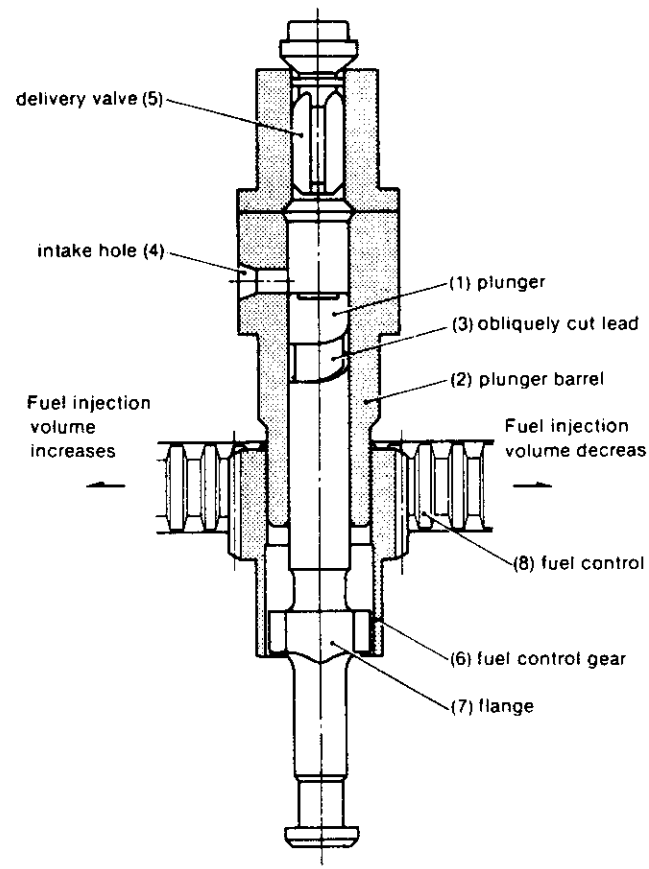


(2) Model 3GMF Y



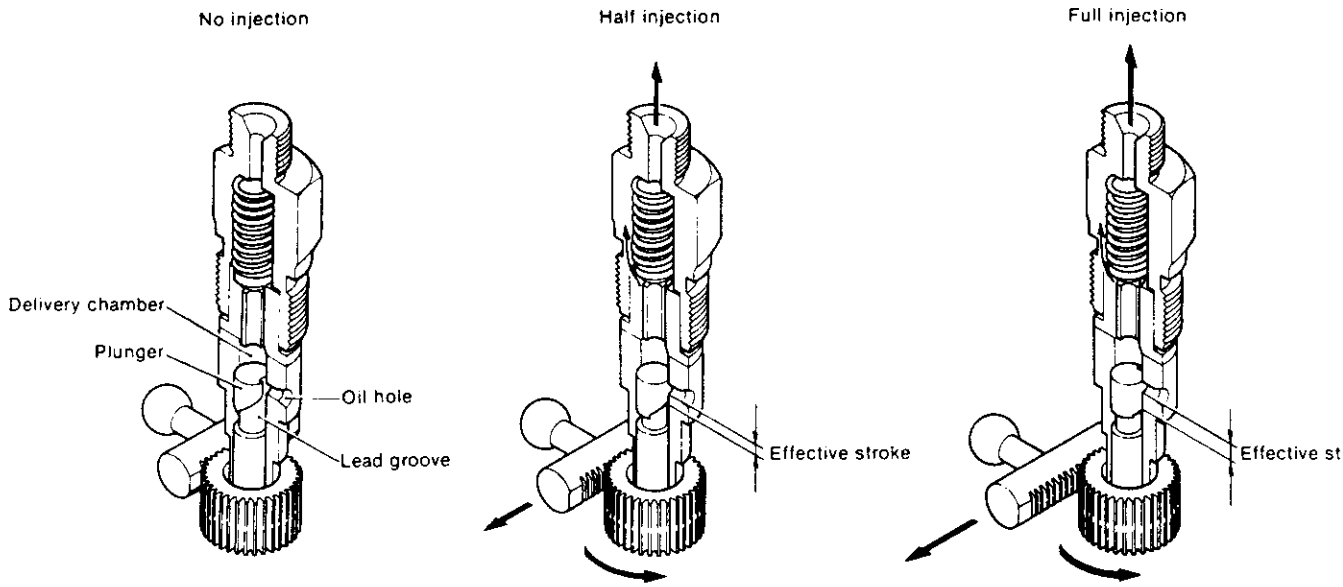
2-3 Operation of fuel injection pump

The fuel injection pump force-feeds the fuel by means of the plunger (1) which operates at a constant stroke. Since the plunger is lap fitted into the plunger barrel (2) for super precison, it can be replaced only as a set. The cylindrical surface of the plunger has an obliquely cut lead (3) and a groove which connects the lead to the plunger head. The plunger has an intake hole (4) through which the fuel passes and is force-fed by the plunger. Then the fuel opens the delivery valve (5), goes through the fuel injection tube, and is injected into the spiral-vortex type pre-combustion chamber from the injection valve. The plunger is fitted with the fuel control gear (6), and its flange (7) fits into the groove which is longitudinally cut into the inner surface of the lower end of the control gear. The fuel control gear is in mesh with the fuel control rack, the motion of which rotates the plunger to constantly vary the amount of fuel injected from zero to maximum.



2-3.1 Fuel control

When the plunger (1) is at bottom dead center, the oil, which comes in through the oil hole, fills the delivery chamber (3) to above the plunger; the oil pressure then builds up as the plunger rises and closes the oil hole, and by opening the delivery valve, is force-fed toward the fuel injection tube. As the plunger, pushed by the plunger guide, rises further, the pressure of the oil between the delivery chamber and the nozzle also increases. When this oil pressure builds up to 155 to 165 kg/cm², the nozzle opens, and the fuel oil is injected into the spiral vortex type combustion chamber. However, if the plunger keeps rising and the lead groove (4) lines up with the oil hole (2), the oil under high pressure in the delivery chamber passes the lead from the longitudinal groove up the lead and is driven back into the suction chamber from the oil hole. At the same time force feeding of the fuel is suspended.

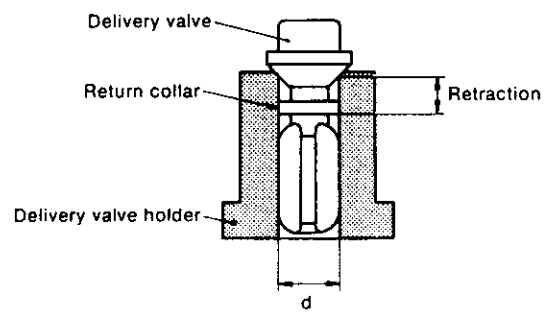


As a result of the above action, the plunger is rotated by the fuel control rack and the angle of this rotation changes the effective stroke of the plunger and controls the discharge of the pump. Also, when the fuel control rack lines up the longitudinal groove on the plunger with the oil hole, the oil hole does not close, despite the rise of the plunger, but rather the fuel is driven back to the suction chamber. As a result the fuel is not force-fed but the amount of injection is reduced to zero. At this time the fuel control rack is at the cylinder side end; when it reaches the opposite side end the maximum amount of fuel is injected. Before the maximum injection level is reached, the fuel injection control shaft regulates the amount of fuel injected to the normal operation level.

NOTE: The plunger is an integral part of the plunger barrel and takes in and compresses fuel by reciprocating inside the plunger barrel. The plunger and plunger barrel are precisely machined, and because the plunger is driven in an extremely small space, the two should be used together and should not be changed with other cylinders.

2-3.2 Action of the delivery valve and the sucking-back of fuel

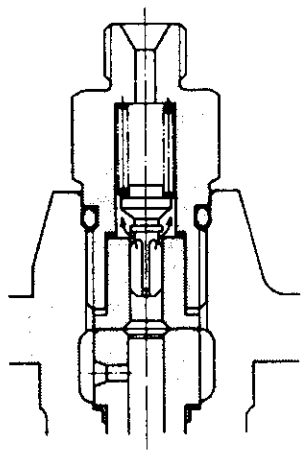
The delivery valve on top of the plunger prevents the fuel within the injection tube from flowing backward toward the plunger side and also serves to suck back the fuel to prevent the backward dripping of the nozzle valve. When the notch (lead) of the plunger comes up to the oil hole of the plunger barrel, the feeding pressure acting on the fuel oil drops, and the delivery valve falls due to the force of the spring. After the sucking-back collar (1) has first shut off the fuel injection tube and the delivery chamber the delivery valve drops further until it comes into contact with the seat surface. (2) corresponding to the amount of fall (i.e., increase in volume), the fuel oil pressure within the injection tube drops, speeding up the closure of the nozzle valve, and sucking up the fuel before it drips back, This enhances the durability of the nozzle and improves fuel oil combustion.



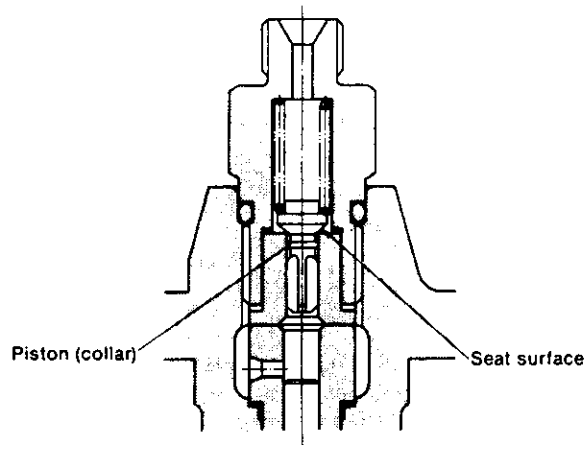
Amount of fuel retraction	$\pi/4\ d^2\ell$ = 23.5mm³/stroke (0.0014in³./st.)

2-4 Disassembly of fuel injection pump

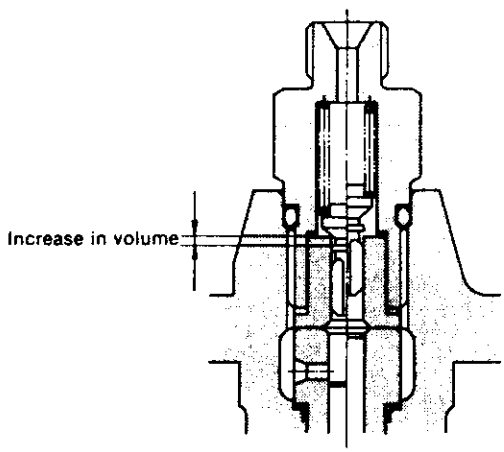
As a rule, the injection pump should not be disassembled, but when disassembly is unavoidable, proceed as described below.



Open



Close

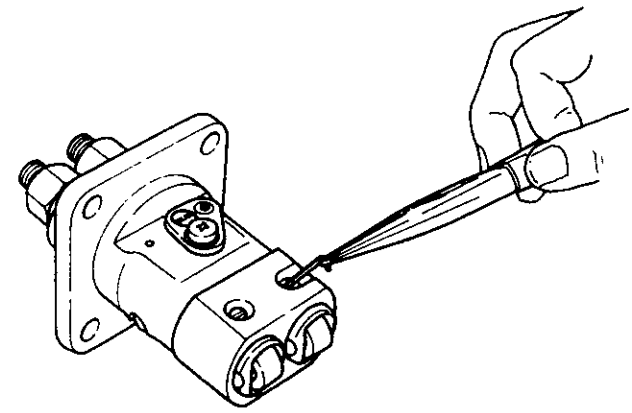


Retraction of fuel

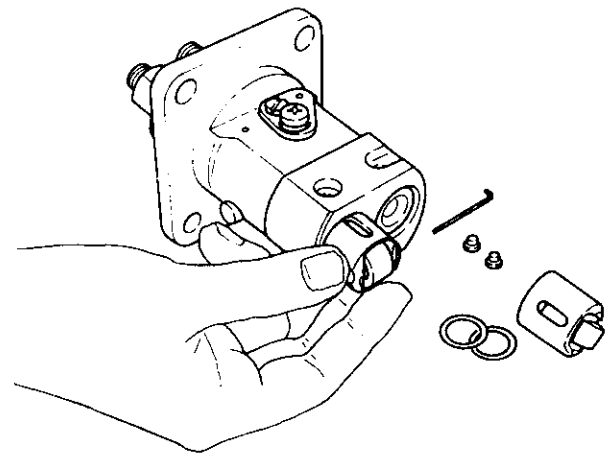
Dismantling of fuel pump

The cylinders are classified as No.1, No.2 and No.3 from the left when facing the name plate which is fitted on the upper part of the fuel injection pump. When dismantling, it is necessary to prepare pans or vessels in which to keep the dismantled parts from each cylinder; each part must be placed in the corresponding pan or vessel for each cylinder, namely, No.1, No.2 and No.3 cylinder. If a part is placed in the wrong pan or vessel, reassembly becomes impossible without a pump tester. The following explanation applies to the pump of the 2 cylinder type engine (model 2GMFY), but it equally applies to that of the 3 cylinder type engine (model 3GMFY) which merely has an additional set.

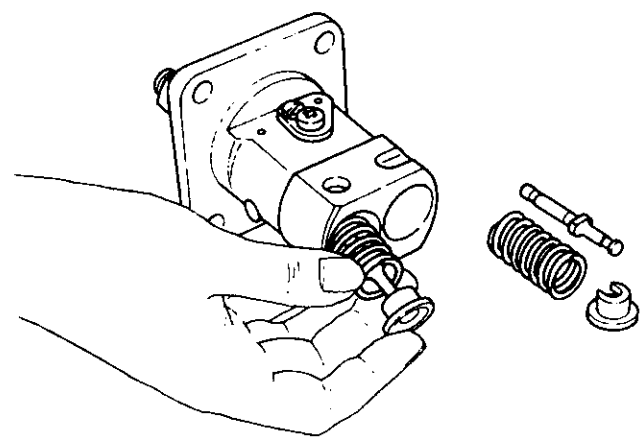
(1) Remove the plunger guide stopper pin with needle nose pliers.



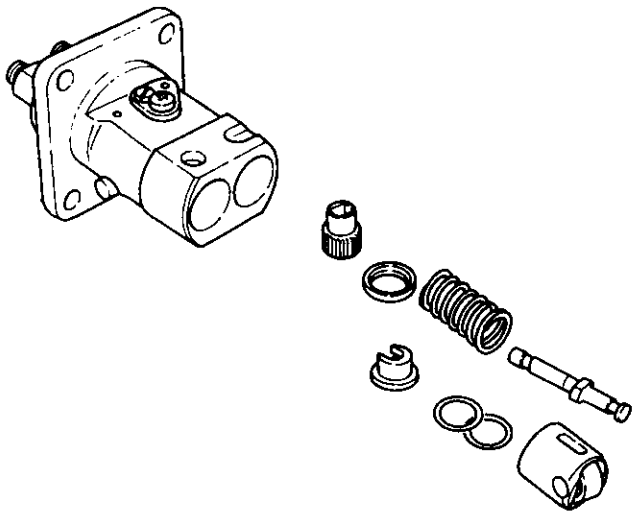
(2) Remove the No.1 plunger guide stopper.
The stopper can be removed by pushing the plunger guide down with the palm of your hand.
(3) Remove the No.1 plunger guide.



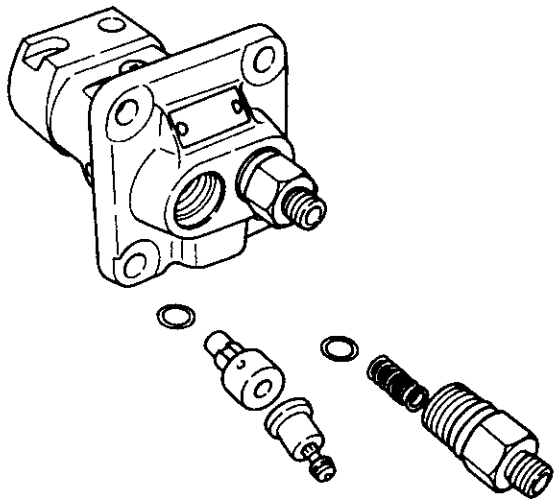
(4) Remove the No.1 plunger and plunger spring lower retainer and plunger shim; be careful not to damage the plunger.
(5) Remove the No.1 plunger spring.



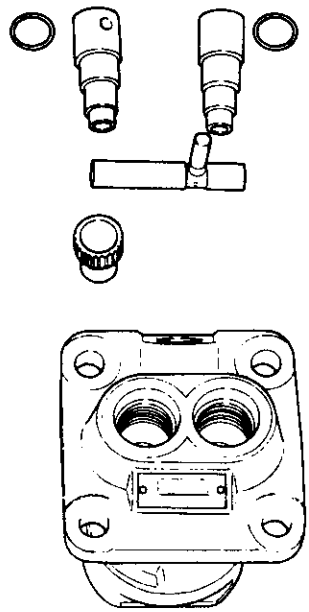
(6) Remove the No.1 plunger spring upper retainer, using your fingers or tweezers.
(7) Remove the No.1 control sleeve



(8) Remove the No.1 delivery valve holder; be careful not to damage the O-ring.
(9) Remove the No.1 delivery valve spring.
(10) Remove the No.1 delivery valve, delivery valve seat and packing.



(11) Remove the No.1 plunger barrel; be careful not to damage the face that matches the delivery valve seat.
(12) Remove the No.1 plunger barrel packing.
(13) For No.2 cylinder, repeat the above steps (2) through (11).
(14) The above item also applies to No.3 cylinder for the 3 cylinder type engine.
(15) Remove the control rack.



NOTES: 1) Line up the plunger valve and the plunger, and put them in order.
2) Immerse the delivery valve, plunger, etc. in clean oil.
3) Do not loosen or remove the injection control plate, etc.

2-5 Inspecting injection pump parts

2-5.1 Rinse each component part in clean light oil before inspecting it.

NOTE: Do not touch the sliding surface of the plunger and the delivery valve with your fingers during handling.

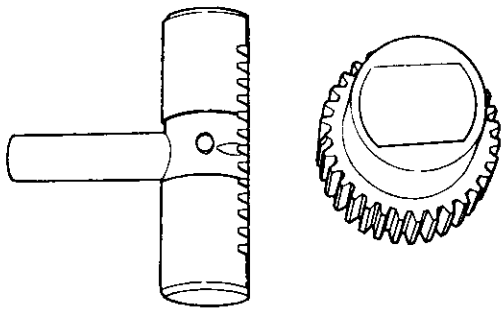
2-5.2 Tappet

Inspect the cam sliding surface of the tappet roller for wear, scoring and peeling; replace the tappet and roller assembly when the total tappet and roller play exceeds 0.3mm.

2-5.3 Control rack and pinion

(1) Check control rack teeth and sliding surface for damage and abnormalities. If found, replace.
NOTE: When replacing control rack, adjust fuel discharge amount with a fuel injection pump tester and stamp a rack mark.

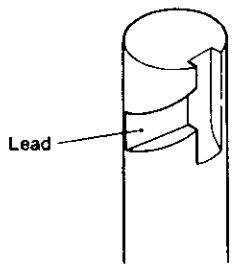
(2) Replace pinion if teeth are damaged or worn unevenly.



(3) If the control rack does not move smoothly when a force of within 60g is applied, replace the rack and pinion assembly.

2-5.4 Plunger

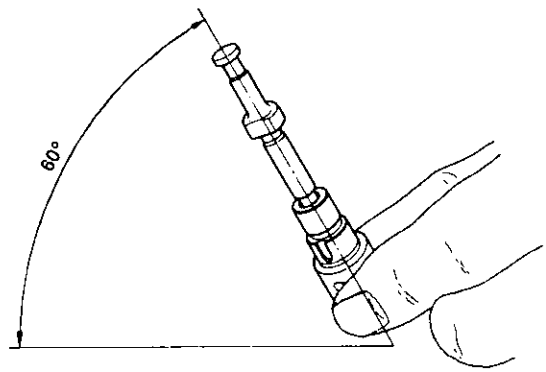
(1) Inspect the plunger for wear, scoring and discoloration around the lead. If any problems are found, conduct a pressure test and replace the plunger and plunger barrel assembly.



(2) Inspect the outside sliding surface of the plunger with a magnifying glass. Lap or replace the plunger and plunger barrel assembly when corrosion, hairline cracks, staining and/or scoring are detected.

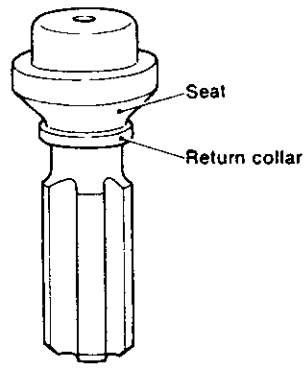
(3) Check the clearance between the plunger collar and control sleeve groove. Replace these parts when wear exceeds the specified limit.

(4) After cleaning the plunger, tilt it approximately 60°, as shown in the figure, and slowly slide it down. Repeat this several times while rotating the plunger. The plunger should slide slowly and smoothly. If it slides too quickly, or binds along the way, repair or replace it.

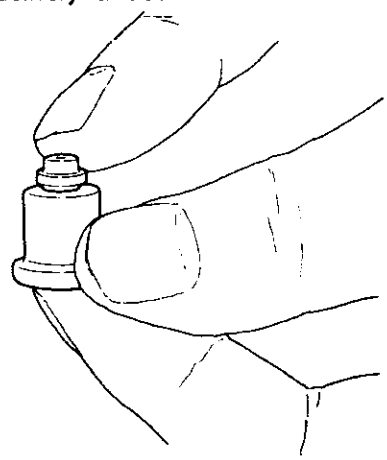


2-5.5 Delivery valve

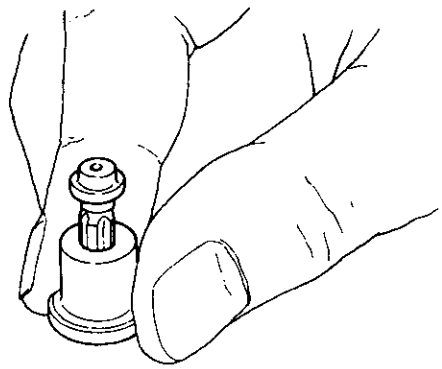
(1) Replace the delivery valve if the return collar and seat are scored, dented or worn.



(2) Raise the delivery valve and put a finger over the hole on the valve seat bottom. Let go of the delivery valve. If it sinks quickly and stops at the position where the suck-back collar closes the valve seat hole, the delivery valve may be considered normal. If this is not the case, replace the delivery valve as a set.



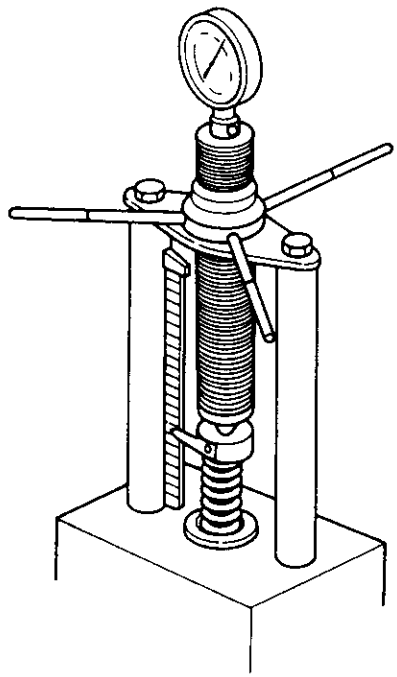
(3) Place your finger over the hole in the bottom of the valve seat and insert the valve into the valve body. If the valve returns to its original position when you remove your finger, the valve is okay. If some defect is found, replace with a new valve.
(4) If the valve closes completely by its own weight when you remove your finger from the hole on the bottom of the valve seat, the valve is okay. If it doesn't close perfectly replace with a new valve.



NOTE: When using a brand-new set, wash off the rustproof oil with clean oil or gasoline. Then, wash once more with clean oil, and follow the steps outlined above.

2-5.6 Plunger spring and delivery valve spring

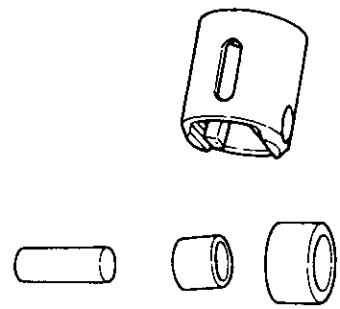
Inspect the plunger spring and delivery valve spring for fractured coils, rust, inclination and permanent strain. Replace the spring when faulty.



	Free length	Set length	Set load
Plunger spring	35.5mm (1.3976in.)	29.5mm (1.1614in.)	11.59 ±1.1 kg (23.13 ~ 27.98 lb)
Delivery valve spring	21mm (0.8268in.)	17.25mm (0.6791in.)	2.4 ±0.24 kg (4.76 ~ 5.82 lb)

2-5.7 Plunger guide

Check the tappet roller (Inside and outside) and roller pin for damage and uneven wear, and replace if required.
Measure the clearance between the plunger and plunger guide. If the clearance exceeds the limit, replace.



mm (in.)

Clearance limit	0.3 (0.0118)

2-6 Assembling the fuel injection pump

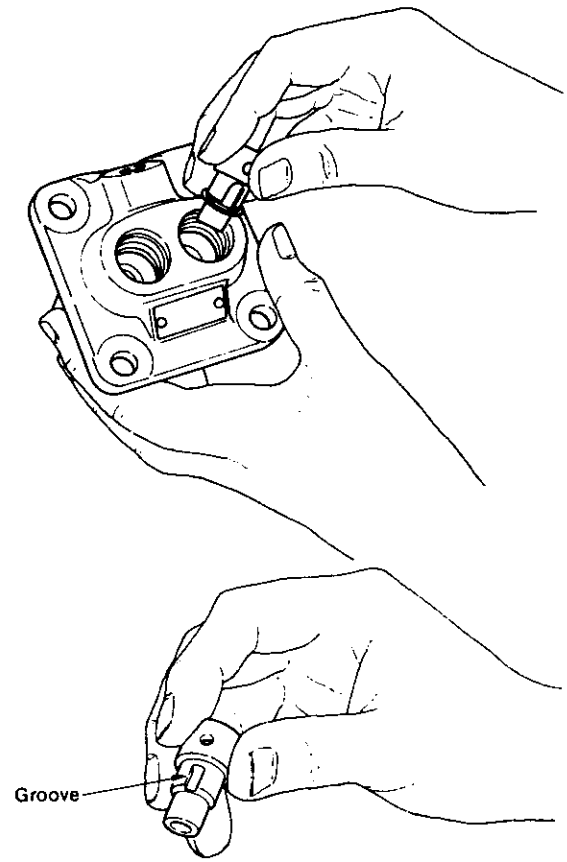
NOTES: 1) After inspection, divide the components into two groups, i.e. the components to be replaced, and those that are reusable. Rinse the components and store the two groups separately.
2) Replace the packing with a new one.

2GMFY, 3GMFY

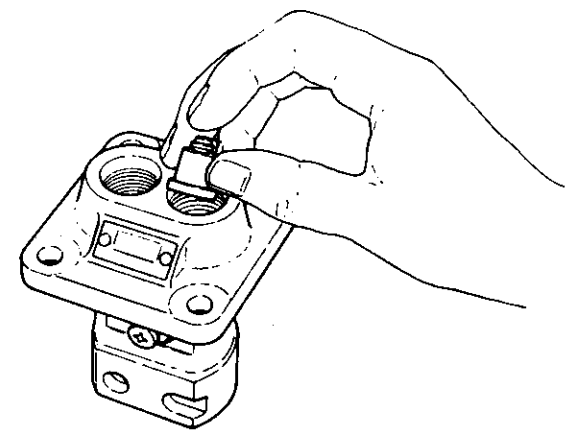
To ensure that the injection pump is correctly reassembled, the following points must be kept in mind:

- The parts for each cylinder must not be mixed together.
- When parts are replaced, the parts for each cylinder must always be replaced at the same time.
- When assembling, parts must be washed in fuel oil and matching marks and scribe lines must be lined up.

(1) Install the No.1 plunger barrel packing.
(2) Insert the No.1 plunger barrel by aligning the groove of the barrel lock pin.



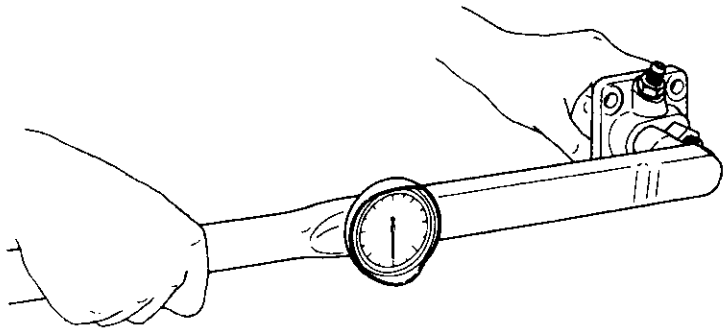
(3) Install the No.1 delivery valve, delivery valve seat and packing.



NOTE: If the delivery valve tip projects noticeably above the top of the main unit of the pump, the plunger barrel has been installed incorrectly, and must be re-attached.

(4) Insert the No.1 delivery valve spring.

(5) Tighten the No.1 delivery valve holder.



kgf-m(ft-lb)

Tightening torque	4.0 ~ 4.5 (28.92 ~ 32.54)

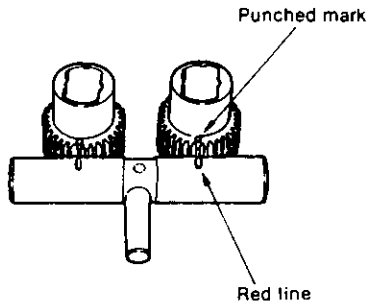
NOTE: Tighten the delivery valve holder with a torque wrench after attaching the plunger and while checking the fuel control rack for sliding motion.

(6) With the matching mark of the fuel control rack directed towards the lower part of the main unit of the pump, attach the fuel control rack to the main unit.

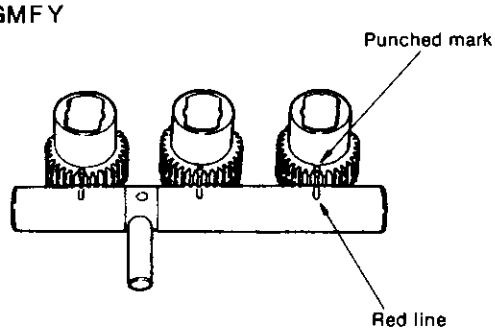
NOTE: Make sure the fuel control rack moves smoothly along its entire stroke.

(7) By aligning the matching mark on the fuel control pinion with that on the fuel control rack, attach the fuel control pinion to the main unit.

2GMFY

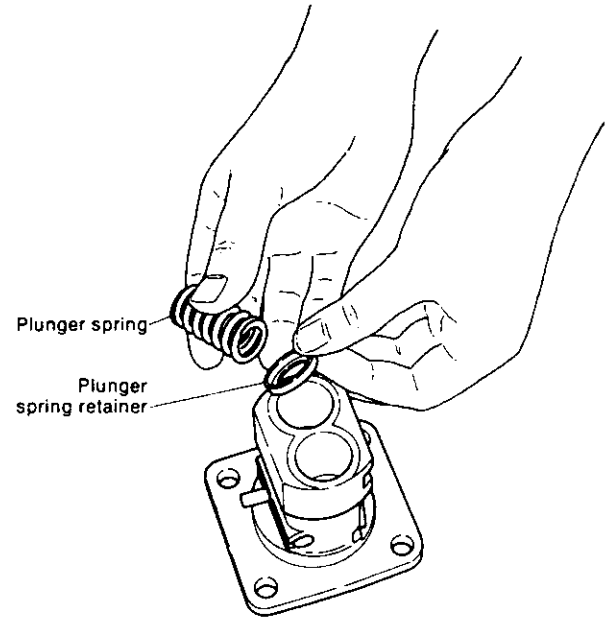


3GMFY



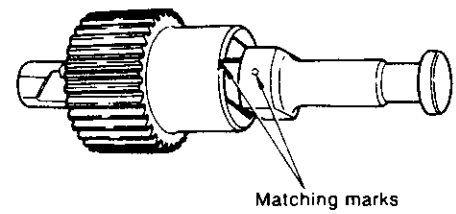
NOTE: After attaching the fuel control pinion to the main unit, check its meshing by moving the fuel control rack.

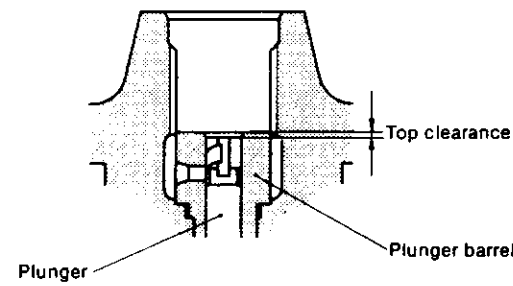
(8) Insert the No.1 plunger spring retainer and attach the plunger spring to the main unit.



NOTE: The plunger spring retainer should face the underside the pump.

(9) After aligning the matching mark on the plunger flange with that on the fuel control pinion, attach the plunger to the main unit.





NOTE: By inverting and standing the main unit of the pump upright attach the plunger to it carefully.

(10) Install the No.1 plunger spring lower retainer. Make sure that it is not installed backwards.

(11) Insert the plunger shim.

NOTE: Insert the same number of shims with the same thickness as those inserted before disassembling the pump. After re-assembling the pump, measure and adjust the top clearance of the plunger.

(12) Insert the No.1 plunger guide.
(13) Insert the No.1 plunger guide stopper.
(14) For the pump of the 2 cylinder type engine, repeat the above steps for No.2 cylinder.
(15) For the pump of the 3 cylinder type engine, repeat the above steps for No.3 cylinder.
(16) Install the plunger guide stopper pin.
(17) After attaching tighten the delivery valve holder with a torque wrench.

kgf-m (ft-lb)

Tightening torque	4.0 ~ 4.5 (28.92 ~ 32.54)

NOTE: When the tightening torque of the delivery valve holder exceeds the prescribed torque, the plunger will be distorted, the sliding resistance of the control rack will increase, and proper performance will not be obtained. Moreover, excessive tightening will damage the pump body and delivery valve gasket, and cause a variety of other problems.

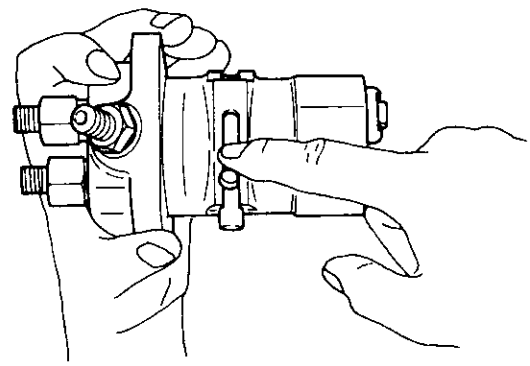
2-7 Inspection after reassembly

When the engine doesn't run smoothly and the injection pump is suspected as being the cause, or when the pump has been disassembled and parts replaced, always conduct the following tests.

2-7.1 Control rack resistance test

After reassembling the pump, wash it in clean fuel, move the rack and check resistance as follows:

(1) This test is performed to determine the resistance of the control rack. When the resistance is large, the engine will run irregularly or race suddenly.
(2) Place the pump on its side, hold the control rack up and allow it to slide down by its own weight. The rack should slide smoothly over its entire stroke. Place the pump on end and perform the above test again; check for any abnormalities. [Resistance below 60g (0.132 lb)]
(3) Since a high sliding resistance is probably a result of the following, disassemble the pump and wash or repair it.

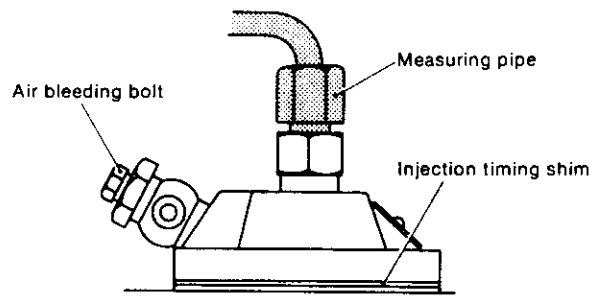


(a) Resistance of the rotating and sliding parts of the plunger assembly is too high.
(b) Delivery valve holder is too tight (plunger barrel distorted).
(c) Control rack or control pinion teeth and control rack outside circumference are dirty or damaged.
(d) Injection pump body control rack hole is damaged.
(e) Plunger barrel packing is not installed correctly and the barrel is distorted. (Since in this case fuel will leak into the crankcase and dilute the lubricating oil, special care must be taken).

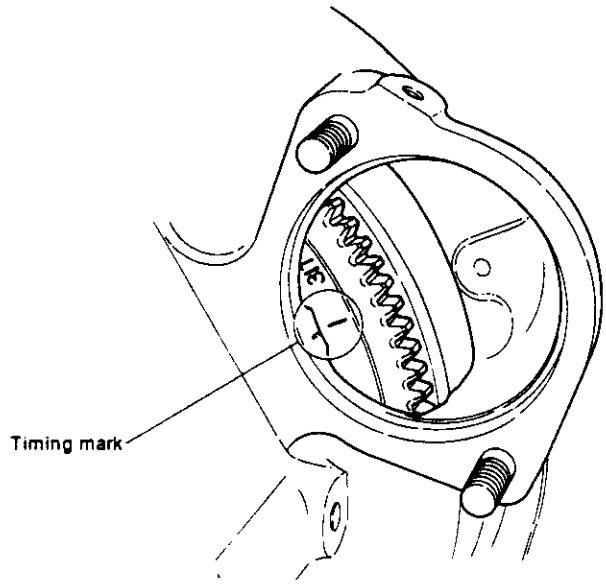
2-7.2 Fuel injection timing

Fuel injection timing is adjusted by timing shims inserted between the pump body and gear case pump mounting seat.
The injection pump must be mounted on the engine, and each cylinder injection timing adjusted.
Adjusting the injection timing

(1) Remove the high pressure pipe from the pump.
(2) Install a measuring pipe if the injection pump does not have a nipple on the delivery side.
(3) Bleed the air from the injection pump.



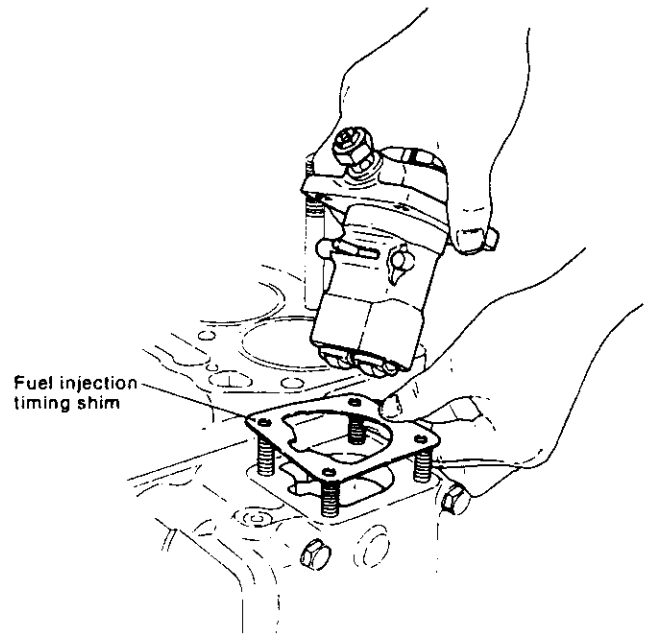
(4) Set the control rack to the middle fuel injection position (Pull the lever when setting the accelerator lever.)
(5) Turn the crankshaft slowly by hand, and read the timing mark (TD) on the flywheel the instant fuel appears at the measuring pipe or pipe joint nipple.
(FID+ Fuel injection from delivery valve.)



(6) If the injection timing is off, add plunger shims when the timing is slow, and remove shims when the timing is fast. Adjust the timing of every pump in the same manner. (Refer to item, "Plunger head gap adjustment".)
(7) After the injection timing of every pump has been matched, recheck the injection timing as described in item (5) above. If the injection timing is not properly set, adjust it with the timing shims.

		2GMFY	3GMFY
Fuel injection timing		bTDC15° (FID)	bTDC18° (FID)
Fuel injection timing shim	0.2mm (0.008in.)	3 shims 124950-01931	2 shims 121450-01931
	0.3mm (0.012in.)	1 shim 124950-01941	1 shim 121450-01941
	Set No.	124950-01951	121450-01951

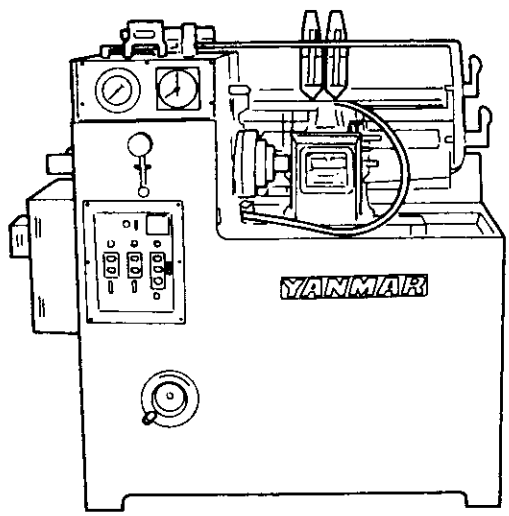
The thickness of the plunger location adjusting shim and the injection timing adjusting plate is 0.1 mm and by this the injection timing can be changed by approximately 1° on the crankshaft.



(8) Finally, turn the crankshaft slowly and confirm that it turns easily. If it is stiff or does not rotate, the plunger head gap is too small.

2-8 Injection pump adjustment

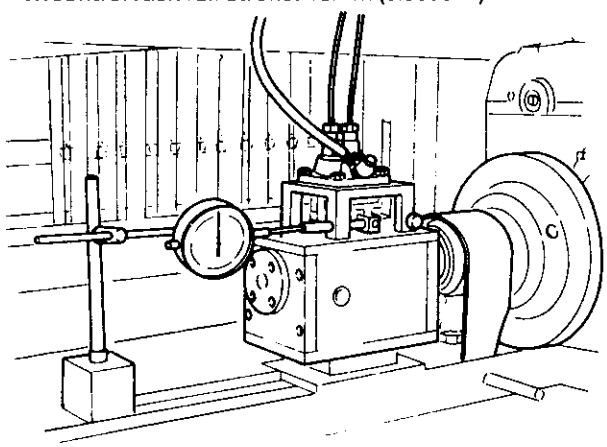
The injection pump is adjusted with an injection pump tester after reassembly.



2-8.1 Setting pump on tester

(1) After the injection pump has been disassembled and reassembled, install it on a pump tester
...cam lift: 7mm (0.276in.).

(2) Confirm that the control rack slides smoothly. If it does not, inspect the injection pump and repair it so that the rack slides smoothly
...control rack full stroke: 15mm (0.5905in.).

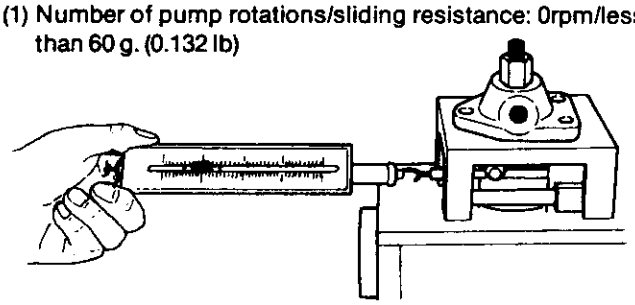


(3) Run the pump tester at low speed, loosen the air bleeder screw, and bleed the air from the injection pump.

2-8.2 Measuring the sliding resistance of the fuel control rack

Measure the sliding resistance of the fuel control rack with a spring scale (balance).

(1) Number of pump rotations/sliding resistance: 0rpm/less than 60 g. (0.132 lb)



NOTE: If the sliding resistance is unsatisfactory, disassemble, inspect and repair the fuel control rack.

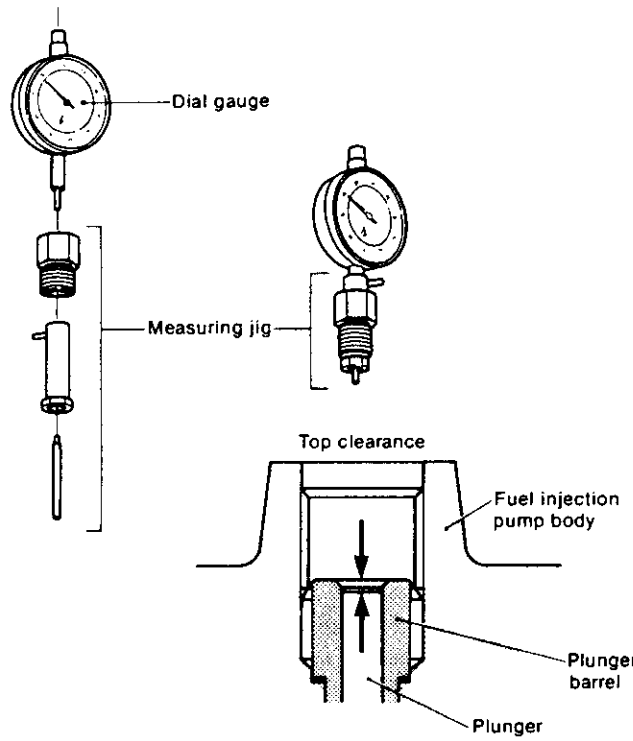
2-8.3 Adjusting the plunger top clearance

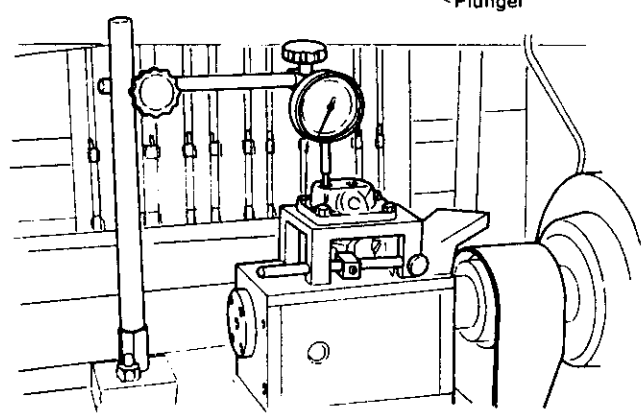
(1) Set the pump installation dimension (end of plunger barrel when the roller is on the cam base cycle) at 76 ±0.05mm (2.9902 ~ 2.9941in.), remove the delivery valve holder and delivery valve, and set the plunger to top dead center by turning the camshaft. Measure the difference in height (head gap) between the end of the plunger and the end of the plunger barrel using a dial gauge.

mm (in.)

Plunger top clearance	1.0 ±0.05 (0.0374 ~ 0.0398)

(2) Using the plunger top clearance measuring jig
1) Install a dial gauge on the measuring jig.
2) Stand the measuring jig on a stool and set the dial gauge pointer to O.
3) Remove the pump delivery valve and install the measuring jig.
4) Turn the camshaft to set the plunger to top dead center and read the dial gauge. The value given is the plunger top clearance.





(3) When the plunger top clearance is larger than the prescribed value, remove the plunger guide and insert plunger shims between the plunger spring lower retainer and the plunger guide. Adjust each pump in the same manner.

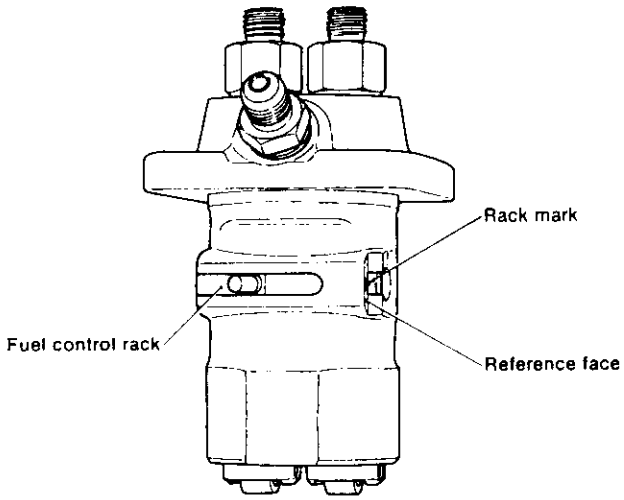
Plunger shim thickness	0.1mm (0.004in.)	174307-51710
	0.2mm (0.008in.)	174307-51720
	0.3mm (0.012in.)	174307-51730

(4) After rechecking adjustment, install the delivery valve.

Delivery valve holder tightening torque	4.0 ~ 4.5 kgf-m (29 ~ 32.6 lb-ft)

2-8.4 Checking the cylinder injection interval

(1) Align the control rack punch mark with the pump reference face.



(2) Turn the pump by hand to check the No.1 cylinder injection timing.
(3) Turn the pump in the prescribed direction and check the No.2/3 cylinder injection timing.
(4) Using the plunger shims, adjust each cylinder injection timing interval.

	For crankshaft angle	For camshaft angle
2GMFY	180° 540° 1 ~ 2 ~ 1	90° 270° 1 ~ 2 ~ 1
3GMFY	240° 240° 240° 1 ~ 3 ~ 2 ~ 1	120° 120° 120° 1 ~ 3 ~ 2 ~ 1

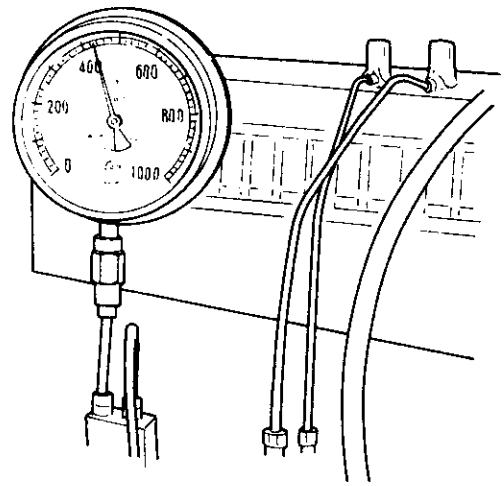
2-8.5 Delivery valve oil-tight test

(1) Install a 1,000 kgf/cm² (14,223 lb/in.²) pressure gauge on the delivery valve holder.
(2) Drive the fuel pump to apply a pressure of approximately 120 kgf/cm² (1,707 lb/in.²) and measure the time required for the pressure to drop from 100 kgf/cm² (1,422 lb/in²) to 90 kgf/cm² (1280 lb/in.²)

Pump speed	200 rpm
Pressure drop standard	20 sec. or more
Pressure drop limit	5 sec. or less

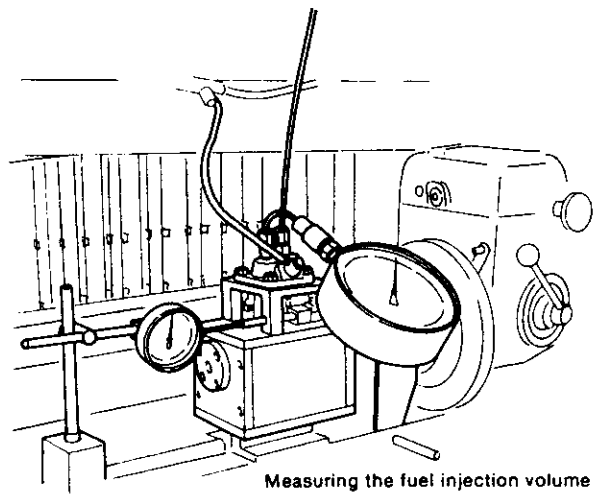
(3) If both the plunger and the delivery valve fail the test, replace them.

2-8.6 Plunger pressure test

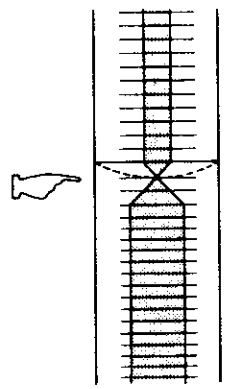


(1) Install a 1,000 kgf/cm² (14,223 lb/in.²) pressure gauge on the delivery valve holder.
(2) Check that there is no oil leaking from the delivery valve holder and high pressure pipe mountings, and that the pressure does not drop suddenly when raised to 500 kgf/cm² (7,112 lb/in.²) or higher.
Pressure gauge AVT 1/2 × 150 × 1,000 kgf/cm²

2-8.7 Measuring the fuel injection volume



Measuring the fuel injection volume



(1) Set the fuel pump camshaft speed.
(2) Check the injection nozzle.

	2GMFY, 3GMFY
Pump speed	1800 rpm
Plunger diameter × stroke	ø6 × 7mm (0.2362 × 0.2756in.)
Injection nozzle type	YDN-OSDYD1
Pressure for fuel injection	170 kgf/cm² (2418 lb/in²)
Amount of injection at rack mark position	20cc ±0.5cc (1.19 ~ 1.25in.³)
Allowable error between cylinders	1cc (0.06in.³) or less
Stroke	1000

NOTE: Mainting the pressure for feeding oil to the injection pump at 0.5 kgf/cm² (7.1 lb/in.²)

2-8.8 Adjustment of injection volume for each cylinder

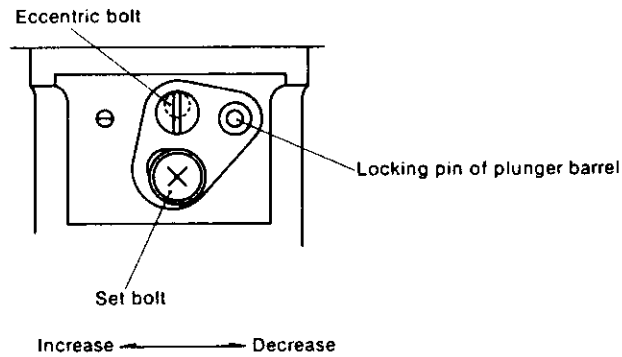
(1) Fluctuation of injection volume
The injection volumes of each cylinder must be adjusted to within 3% of each other.

$$\text{Average injection volume} = \frac{\text{total volume of all cylinder injection}}{\text{number of cylinders}}$$

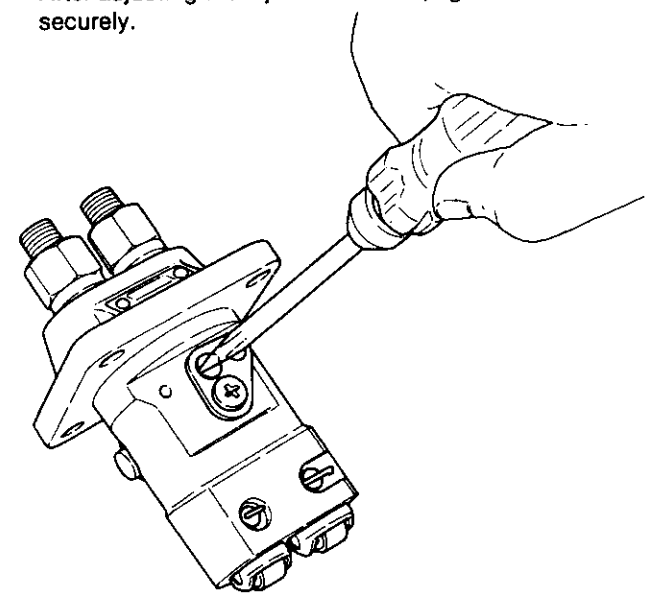
$$\text{Difference} = \frac{\text{Maximum injection volume} - \text{average injection volume}}{\text{Average injection volume}} \times 100$$

When the difference exceeds 3%, adjust the injection volume by sliding the control sleeve and pinion, when the difference exceeds 3%, the engine output will drop and/or one cylinder will overheat.

(2) Adjustment of injection volume
In order to adjust the fluctuation of injection volume for each cylinder, alter the position of the injection volume adjusting plate at the side of the fuel injection of pump body.
The injection volume adjusting plate is operated by the eccentric bolt which is integrated with the locking pin of the plunger barrel and changes the position of the plunger barrel. When the plunger barrel is turned, the relative position of the suction hole with respect to the lower lead of the plunger, changes the injection volume.



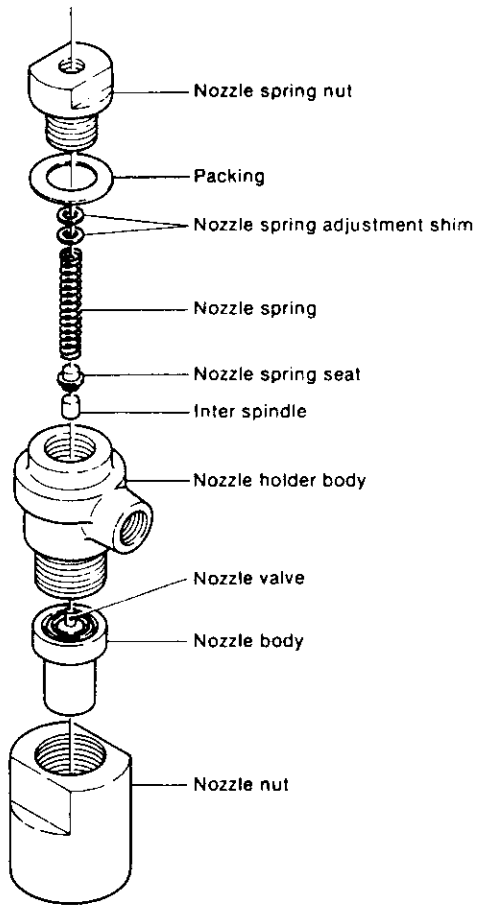
By loosening the set bolt and turning the eccentric bolt clockwise, the position of the pin moves to the leftside to increase the injection volume, and by turning the eccentric bolt counterclockwise, the pin moves to the rightside to decrease the injection volume.
After adjusting the injection volume, tighten the set bolt securely.

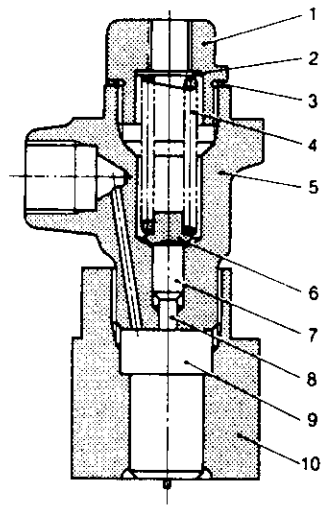


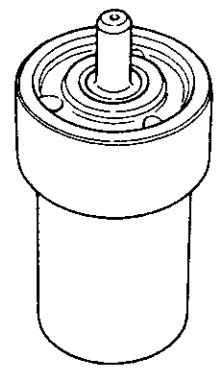
3. Injection Nozzle

3-1 Construction

The injection nozzle atomizes the fuel sent from the injection pump and injects it into the precombustion chamber in the prescribed injection pattern to obtain good combustion through optimum fuel/air mixing.
The main parts of the injection nozzle are the nozzle holder and nozzle body. Since both these parts are exposed to hot combustion gas, they must be extremely durable.
Moreover, since their operation is extremely sensitive to the pressure of the fuel, high precision is required. Both are made of quality alloy steel that has been specially heat treated and lapped, so they must always be handled as a pair.
Common parts are used for the fuel valve of models 2GMFY and 3GMFY.







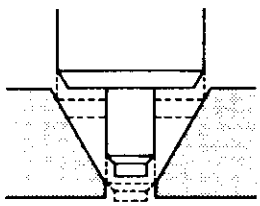
1. Nozzle spring nut
2. Nozzle spring adjustment shim
3. Packing
4. Nozzle spring
5. Nozzle holder body
6. Nozzle spring seat
7. Inter spindle
8. Nozzle valve
9. Nozzle body
10. Nozzle nut

3-2 Specifications for nozzle valve

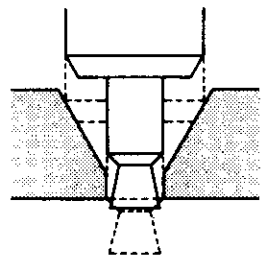
Nozzle	Type of nozzle valve	YDN-OSDYD1 (Throttle)	
	Valve opening pressure	170 ±5 kgf/cm² (2347 ~ 2489 lb/in.²)	160 ±5 kgf/cm² (2205 ~ 2347 lb/in.²)
	Diameter of injection nozzle	ø1mm (0.0394in.)	
	Angle of injection	5° ~ 10°	
Nozzle spring	Free length	30.0mm (1.1811in.)	
	Mounted length	28.7mm (1.1299in.)	
	Mounted load	14.14 kg (31.17 lb)	
Nozzle spring adjusting plate (for adjusting nozzle opening pressure)		0.1mm (0.0039in.)	0.2mm (0.0079in.) 0.3mm (0.0118in.) 0.5mm (0.0197in.)

3-3 Yanmar throttle nozzle

The semi-throttle nozzles used in this engine are designed and manufactured by Yanmar. A semi-throttle nozzle resembles a pintle nozzle, except that with the former the nozzle hole at the end of nozzle and nozzle body are longer and the end of the nozzle is tapered. This nozzle features a "throttling effect": relatively less fuel is injected into the precombustion chamber at the initial stage of injection, and the volume is increased as the nozzle rises. This type of throttle nozzle ideal for small, high-speed engines.



Pintle nozzle



YANMAR semi-throttle nozzle

3-4 Nozzle operation

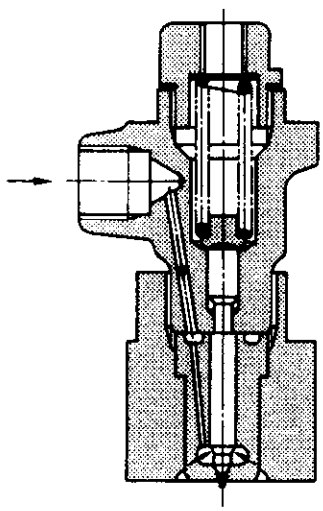
The nozzle is pushed down to its lowest position by the pressure-adjusting nozzle spring and contacts the valve seat of the nozzle body.

Under high pressure, fuel from the fuel pump passes through the hole drilled in the nozzle holder, enters the circular groove at the end of the nozzle body and then enters the pressure chamber at the bottom of the nozzle body.

When the force acting in the axial direction on the differential area of the nozzle at the pressure chamber overcomes the force of the spring, the nozzle is pushed up and the fuel is injected into the precombustion chamber through the throttle hole.

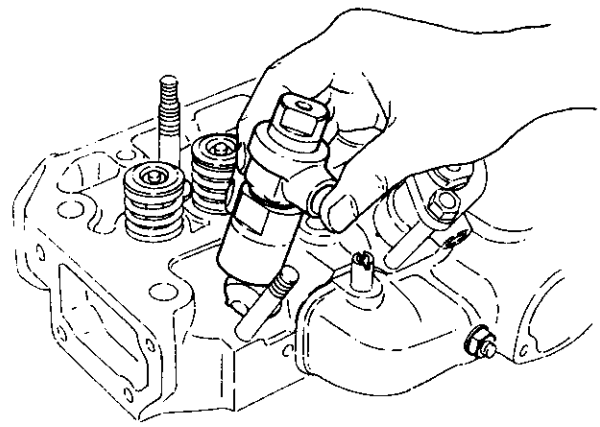
The nozzle is closed again when the pressure in the nozzle body's pressure chamber drops below the force of the spring.

This cycle is repeated at each opening and closing of the injection pump delivery valve.

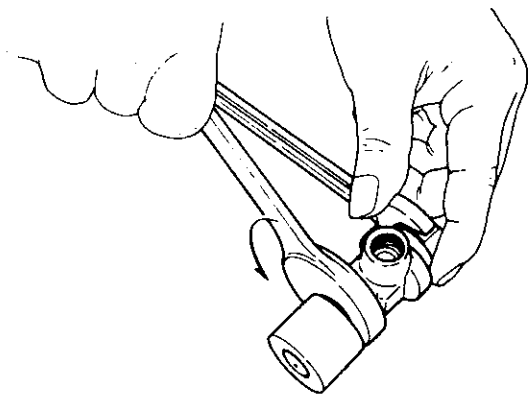


3-5 Disassembly and reassembly

3-5.1 Disassembly sequence



(1) Remove the carbon from the nozzle end.
(2) Loosen the nozzle spring holder.
(3) Remove the nozzle holder body from the nozzle mounting nut.

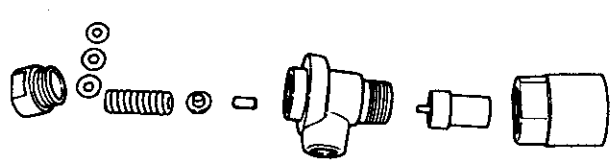


(4) Remove the nozzle body and nozzle ass'y from the nozzle mounting nut.
(5) Remove the nozzle spring retainer from the nozzle holder body, and remove the nozzle spring retainer, inter-spindle etc.

Reassemble in the reverse order of disassembly, paying special attention to the following items.

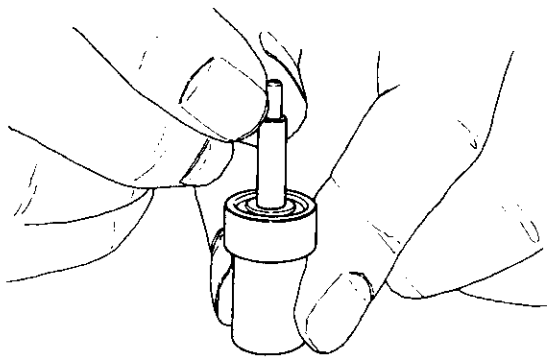
3-5.2 Disassembly and reassembly precautions

(1) The disassembled parts must be washed in fuel oil, and carbon must be completely removed from the end of the nozzle body, the nozzle body and the nozzle mounting nut fitting section.
If reassembled with any carbon remaining, the nozzle will not tighten evenly, causing faulty injection.



(2) Parts for No.1 cylinder and No.2 cylinder must be kept separate. The nozzle body and nozzle must always be handled as a pair.

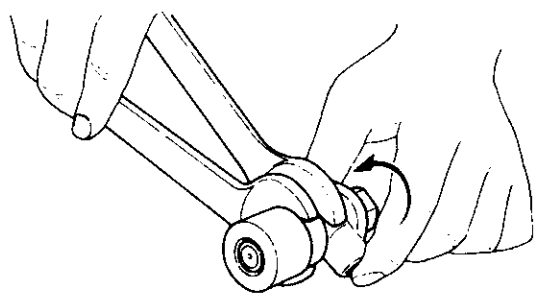
(3) Precautions when using a new nozzle.
First immerse the new nozzle in rust-preventive oil, and then seal it on the outside with seal peel. After removing the seal peel, immerse the nozzle in diesel oil and remove the rust-preventive oil from both the inside and outside of the nozzle.
Stand the nozzle holder upright, lift the nozzle about 1/3 of its length: it should drop smoothly by it own weight when released.



(4) The nozzle must be assembled to the nozzle holder with the nozzle spring retainer loosened.
If the nozzle is installed with the nozzle spring tightened, the nozzle mounting nut will be tightened unevenly and oil will leak from between the end of the nozzle holder body and the end of the nozzle mounting nut, causing faulty injection.

kgf-m (ft-lb)

Nozzle tightening torque	Nozzle nut	10 (72.36)
	Nozzle spring nut	7.0 ~ 8.0 (50.65 ~ 57.89)

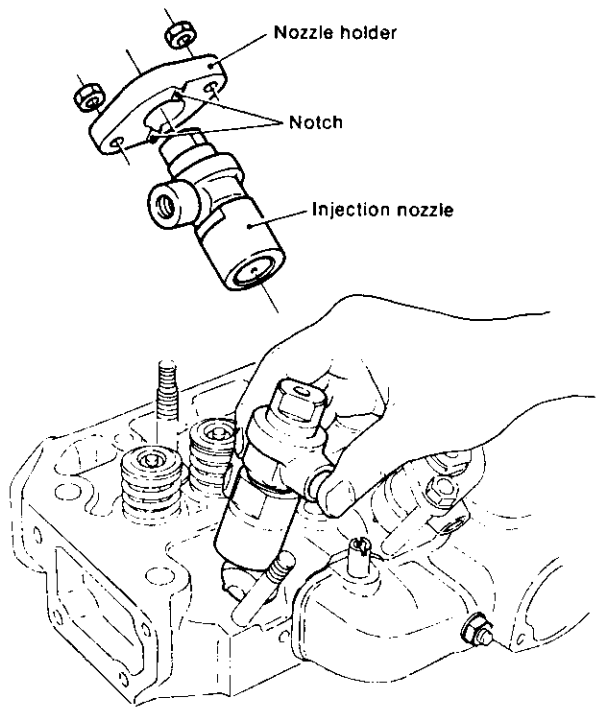


(5) When installing the injection nozzle on the cylinder head, tighten the nozzle holder nuts alternately, being careful to tighten them evenly.

kgf-m (ft-lb)

Tightening torque	2 (14.5)

Moreover, the nozzle holder must be installed with the notch side on the nozzle side.



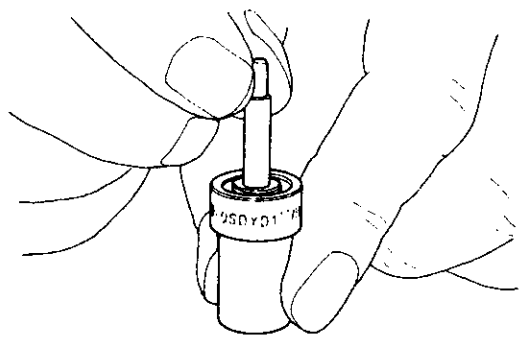
3-6 Injection nozzle inspection and adjustment

3-6.1 Carbon and corrosion on the nozzle body

Inspect the end and sides of the nozzle body for carbon build-up and corrosion. If there is considerable carbon build-up, check the properties of the fuel used, etc.
Replace the body if heavily corroded.

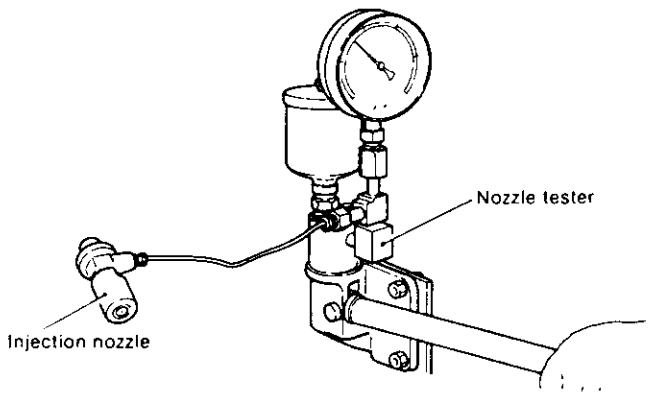
3-6.2 Checking nozzle action

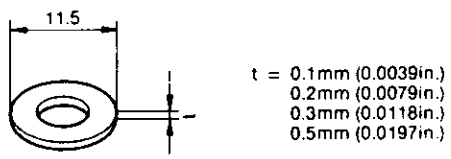
Wash the nozzle in clean fuel oil and hold the nozzle body upright, then lift the nozzle about 1/3 of its length with one hand. The nozzle is in good condition if it drops smoothly by its own weight when released. If the nozzle slides stiffly, repair or replace it.



3-6.3 Adjusting the nozzle injection pressure

Install the injection nozzle to the high pressure pipe of a nozzle tester and slowly operate the lever of the tester. Read the pressure the instant injection from the nozzle begins.
If the injection pressure is lower than the prescribed pressure, remove the nozzle spring holder and adjust the pressure by adding nozzle spring shims.
The injection pressure increases about 10 kgf/cm² (142.2 lb/in.²) when a 0.1mm (0.004in.) shim is added.





Injection pressure	170 ±5 kgf/cm² (2347 ~ 2489 lb/in.²)

3-6.4 Nozzle seat oil tightness check

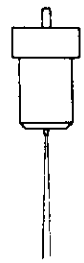
After injecting fuel several times by operating the lever of the nozzle tester, wipe the oil off the injection port. Then raise the pressure to 20 kgf/cm² (284.5 lb/in.²) 140 kgf/cm² (1991 lb/in.²) lower than the prescribed injection pressure. The nozzle is faulty if oil drips from the nozzle. In this case, clean, repair or replace the nozzle.

3-6.5 Checking the spray condition

Adjust the nozzle injection pressure to the prescribed value and check the condition of the spray while operating the tester at 4—6 times/sec. Judge the condition of the spray by referring to the below figure.

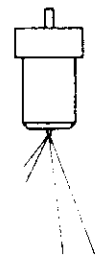
Normal

Stream



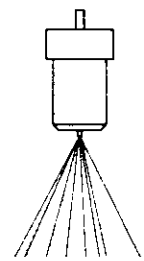
- Injection pressure low
- Nozzle seized
- Nozzle spring broken
- Dirt on valve seat

Spike



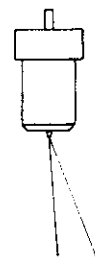
- Injection port damaged or dirty
- Carbon build-up
- Nozzle end abnormally worn

Spray



- Injection port worn
- Carbon build-up

Slanted



- Uneven seat contact
- Injection port damaged or worn
- Carbon build-up

3-6.6 Inspecting the nozzle spring

Inspect the nozzle spring for fractured coils, corrosion, and permanent strain, and replace the spring when faulty.

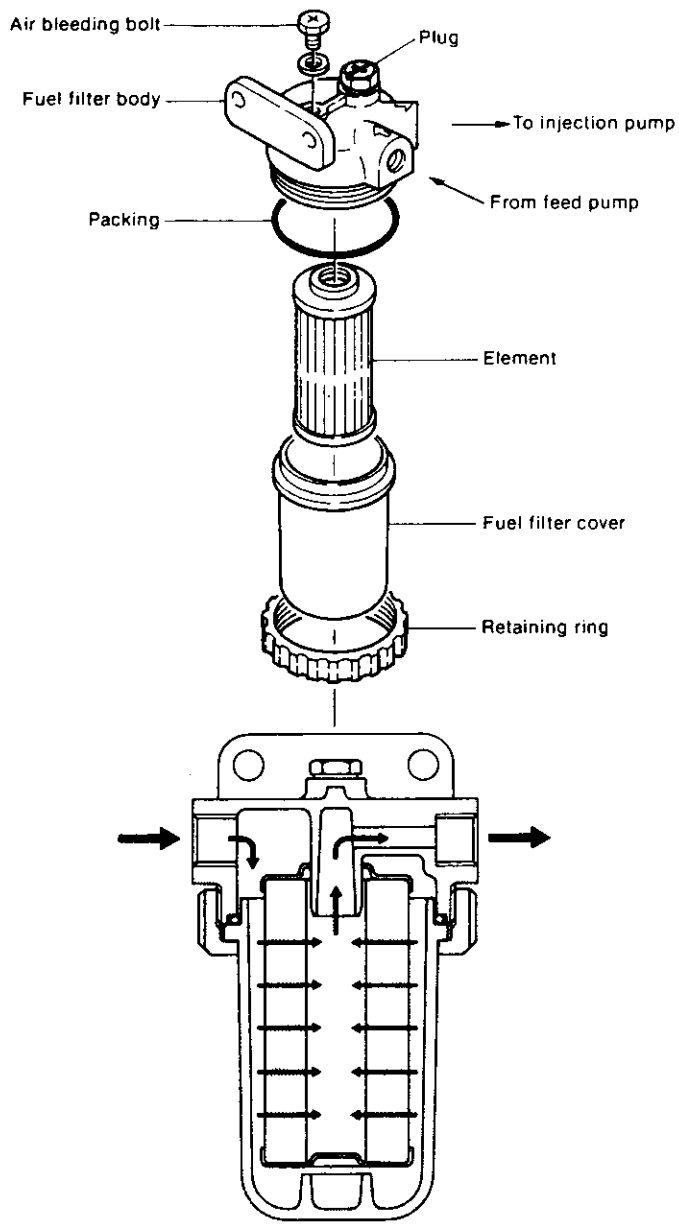
3-6.7 Inspecting the nozzle spring retainer and inter-spindle

Inspect the nozzle spring retainer and inter-spindle for wear and peeling of the contact face, and repair or replace the spring if faulty.

4. Fuel Filter

4-1 Construction

The fuel filter is installed between the feed pump and injection pump, and serves to remove dirt and impurities from the oil fed from the fuel tank through the feed pump.
The fuel filter incorporates a replaceable filter paper element. Fuel from the fuel tank enters the outside of the element and passes through the element under its own pressure. As it passes through, the dirt and impurities in the fuel are filtered out, allowing only clean fuel to enter the interior of the element. The fuel exits from the outlet at the top center of the filter and is sent to the injection pump.
A cross-headed hexagonal bolt is fitted to the fuel filter body. Loosen the bolt with a cross-headed screw driver before starting or after dismantling and reassembly to bleed the air in the fuel system to the fuel oil filter.

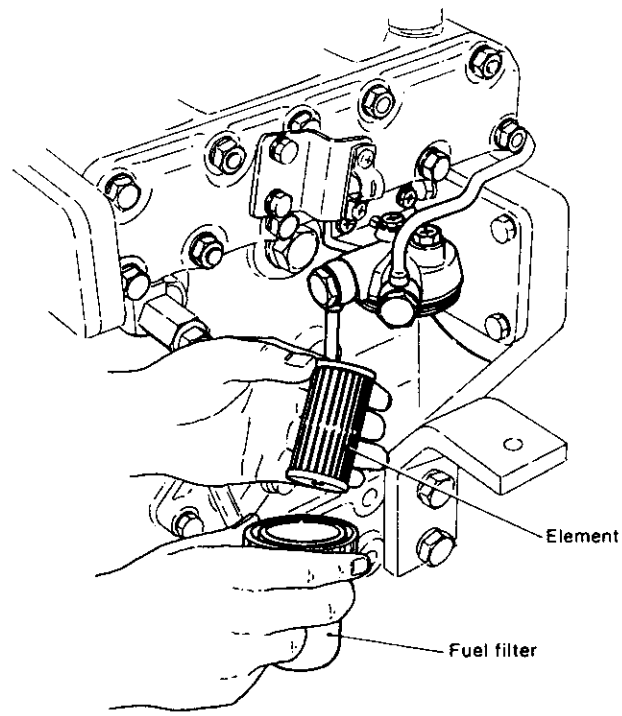


4.2 Specification
(Common to Models 2GMFY 3GMFY)

Filtering Area	333cm² (20.3in.²)
Material of element	Cotton fiber
Filter mesh	10 ~ 15μ

4-3 Inspection

The fuel filter must be periodically inspected. If there is water and sediment in the filter, remove all dirt, rust, etc. by washing the filter with clean fuel.
The normal replacement interval for the element is 250 hours, but the element should be replaced whenever it is dirty or damaged, even if the 250 hour replacement period has not elapsed.

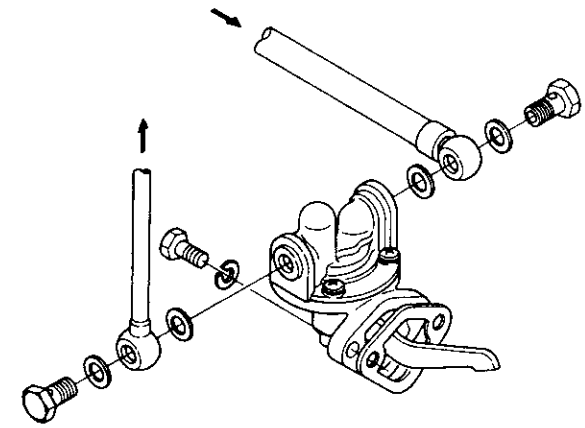


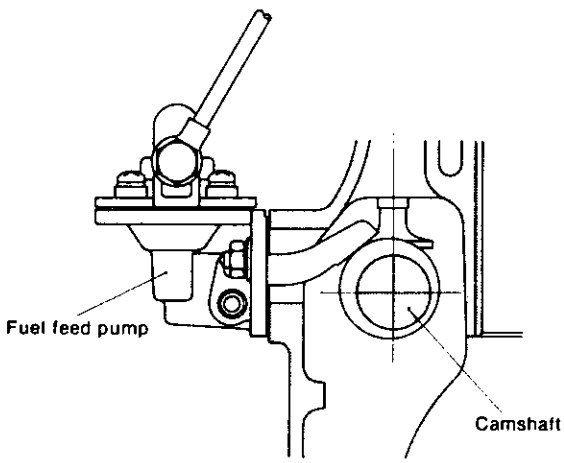
Filter cleaning	First time 50 hours
Filter element replacement	Every 250 hours

5. Fuel Feed Pump

5-1 Construction

The fuel pump feeds the fuel from the fuel tank to the injection pump through the fuel filter. When the fuel tank is installed at a higher position than the fuel filter and injection pump, the fuel will be fed by its head pressure, but if the, fuel tank is lower than the filter and injection pump, a fuel pump is required.
The fuel pump of this engine is a diaphragm type and is installed on the exhaust side of the cylinder body. The diaphragm is operated by the movement of a lever by the fuel feed pump cam at the cam shaft.





2GMFY, 3GMFY

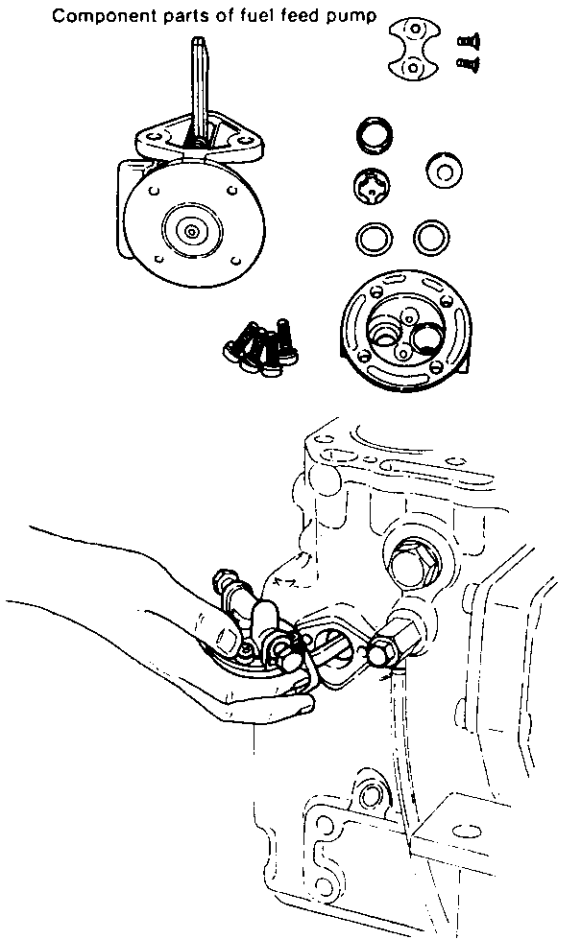
Specifications

Part No.	121256-52020
Suction head	Max. 0.8m (3.15in.)
Capacity	0.3 ℓ/min. at 1000 rpm
Feed pressure	0.1 kgf/cm² (1422 lb/in.²) at 600 ~ 1800 rpm
Suction pressure	−60 mmHg at 600 rpm

5-2 Disassembly and reassembly

5-2.1 Disassembly

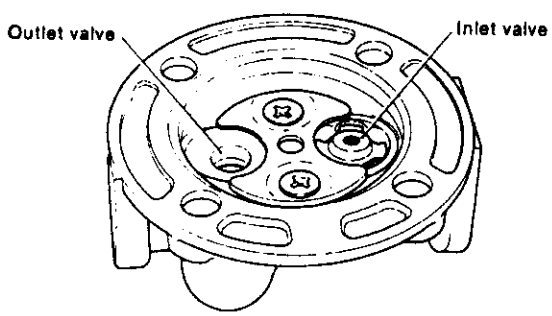
Clean the outside of the pump, scribe a matching mark on the upper body and lower body of the pump, disassemble and put the components in order.



5-2.2 Reassembly

Assemble the pump by reversing the disassembling procedures. Pay close attention to the following:

(1) Clean the components, blow compressed air against them, and inspect. Replace any defective components.
(2) Replace the packings, etc. with new ones.
(3) When mounting the valves, be careful not to mix up the inlet and outlet valves. Also, don't forget the valve packing.



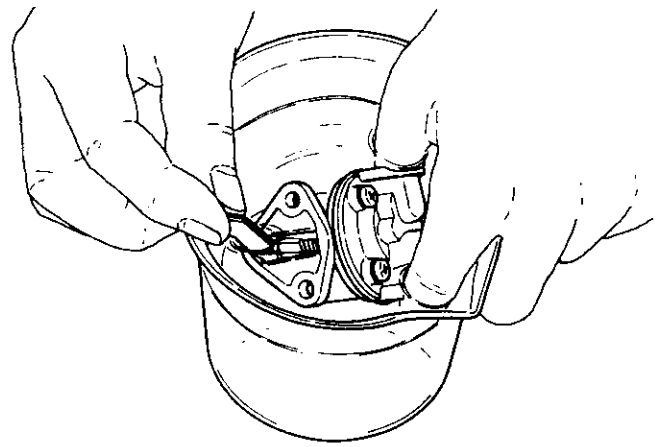
(4) Make sure the diaphragm mounting hole is in the correct position and gently attach the diaphragm to the pump body.
(5) Line up the matching marks on the pump body, and clamp on the pump body evenly.

Tightening torque of screw	30 ±10 kgf-cm (1.45 ~ 2.89 ft-lb)

5-3 Inspecting and adjusting the fuel feed pump

5-3.1 Checking the pump for fuel oil leaks

After removal, immerse the pump in kerosene, stop its outlet port with a finger and, by operating the rocker arm, check for bubbles.
If any bubbles are present, this indicates a defective point which should be replaced.

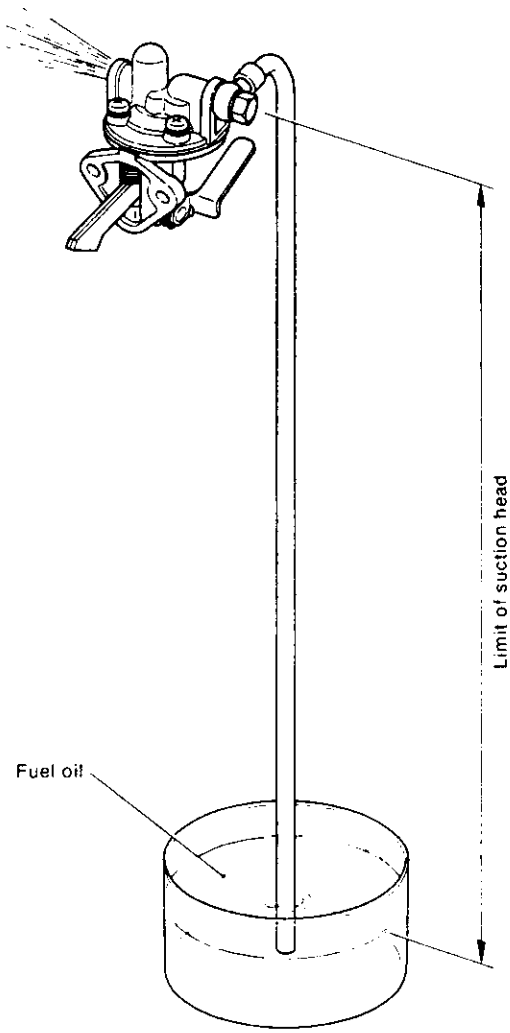


5-3.2 Checking the pump for engine oil leaks

Check pump mounting bolts for looseness and the pump packing for breaks. Retighten any loose bolts and repiace defective packing.

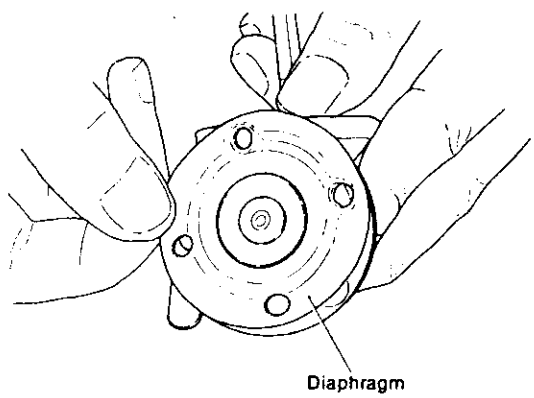
5-3.3 Measuring the sucking power

Attach a piece of vinyl hose to the inlet port, keep the pump at a specified height (head) above the fuel oil level, and operate the rocker arm by hand. If the fuel oil spurts out from the outlet port, the pump is all right. A simpler method of testing pump power is as follows: cover the inlet port with a finger and, by operating the rocker arm by hand, estimate the pump's sucking power by judging the suction on the finger, Although this is not an exact method, it can at least confirm that the diaphragm, valves, etc. are operating.



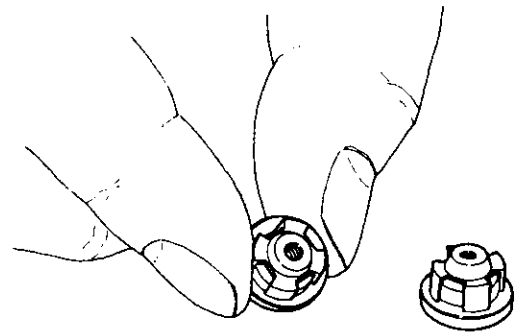
5-3.4 Aging, breakdown and cracking of the diaphragm

Since the diaphragm is constantly in motion, the cloth on its flexible parts becomes thin, cracked, and sometimes breaks down after long periods of use. A broken diaphragm causes fuel oil leakage and often fragments of the diaphragm get into the engine oil, either seriously hampering fuel oil discharge or blocking it altogether.



5-3.5 The contact area and mounting condition of valve

Test the valve seat as follows: Remove the valve and blow into the valve seat from the direction in which the valve spring is mounted. If air leaks, replace-the seat with a new one. If fuel oil leaks as a result of dust, foreign objects, etc. caught in the valve seat, rinse it and clean it by blowing air into it.



5-3.6 Diaphragm spring and rocker arm spring

Check the diaphragm spring and rocker arm spring for permanent deformation, and the rocker arm and rocker pin for wear. If any of these components are defective, replace them with new ones.

NOTE: When it becomes necessary to replace any of these parts, the entire fuel feed pump assembly should be replaced.

CHAPTER 4
GOVERNOR

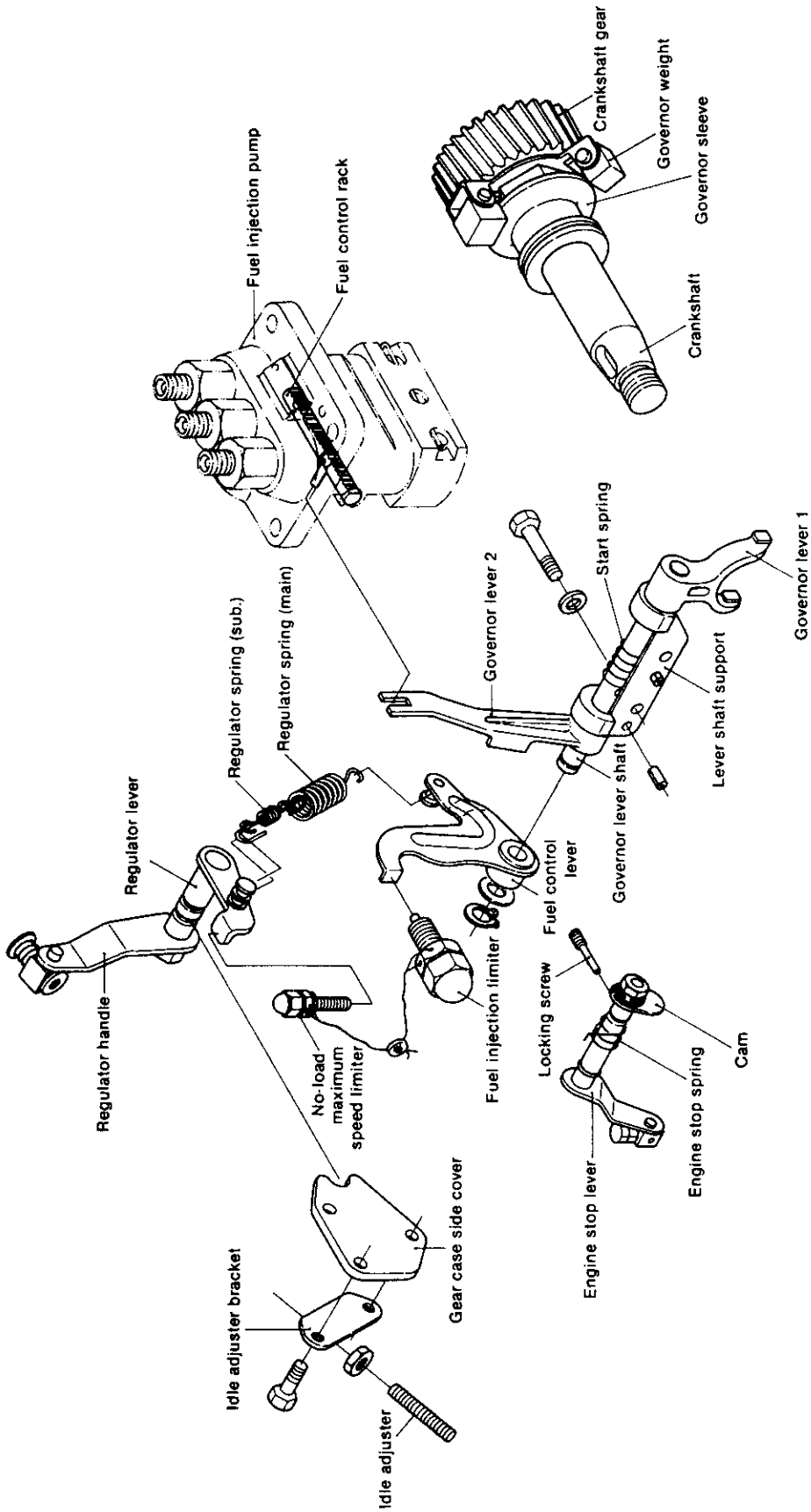
1. Governor 4-1
2. Injection Limiter 4-8
3. No-Load Maximum Speed Limiter 4-9
4. Idling Adjuster 4-10
5. Engine Stop Lever 4-11

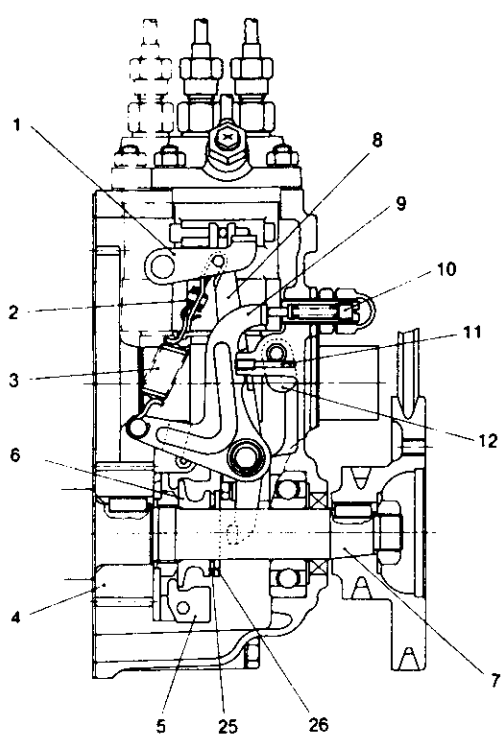
1. Governor

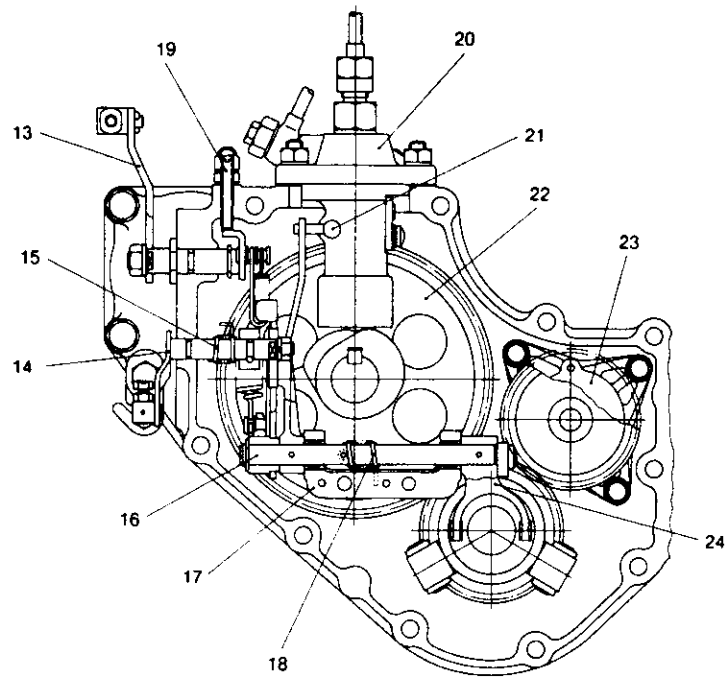
The governor serves to keep engine speed constant by automatically adjusting the amount of fuel supplied to the engine according to changes in the load. This protects the engine against sudden changes in the load, such as sudden disengagement of the clutch, the propeller leaving the water in rough weather, or other cases where the engine is suddenly accelerated.

This engine employs an all-speed governor in which the centrifugal force of the governor weight, produced by rotation of the crankshaft, and the load of the regulator spring are balanced.
The governor is remotely controlled by a wire. Refer to the "Control System" chapter for details.

1-1. Construction



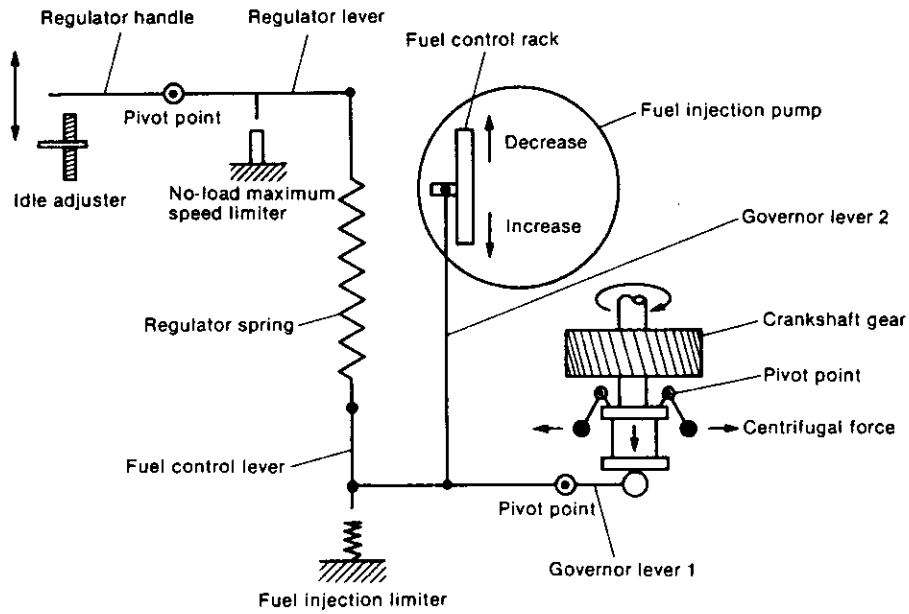




1 Regulator lever
2 Regulator spring (sub.)
3 Regulator spring (main)
4 Crankshaft gear
5 Governor weight
6 Governor sleeve
7 Crankshaft
8 Governor lever 2
9 Fuel control lever
10 Fuel injection limiter
11 Locking screw
12 Engine stop cam
13 Regulator handle
14 Engine stop lever
15 Engine stop spring
16 Governor lever shaft
17 Governor lever shaft support
18 Start spring
19 No-load maximum speed limiter
20 Fuel injection pump
21 Fuel control rack
22 Camshaft gear
23 Lubricating oil pump
24 Governor lever 1
25 Thrust needle bearing
26 Thrust collar

1-2 Operation

The position of the two governor weights (open and closed) is regulated by the speed of the engine. The centrifugal force of the governor weights pivots around the governor weight pin and is changed to axial force that acts on the sleeve. This force is transmitted to governor lever 2 through governor lever 1, and lever 1 shifts the fuel control rack to increase or decrease the fuel supply. The governor lever is stabilized at the point at which the force produced by the governor weight is balanced with the load of the regulator spring connecting the regulator lever and fuel control lever. When the speed is reduced by application of a load, the force of the regulator spring pushes the governor sleeve in the "fuel increase" direction, stabilizing the engine speed by changing the position of the regulator lever.



1-3 Performance

No-load maximum speed		3750^{+50}_{0} rpm
No-load minimum speed		850 ±25 rpm
Instant speed regulation	δi	10% or less
Stabilization time	ts	10 sec. or less
Stabilized speed regulation	δs	5% or less
Fluctuation of rotation		40 rpm or less

Instant speed regulation $\delta i = \left|\frac{ni - nr}{nr}\right| \times 100$

Stabilized speed regulation $\delta s = \left|\frac{ns - nr}{nr}\right| \times 100$

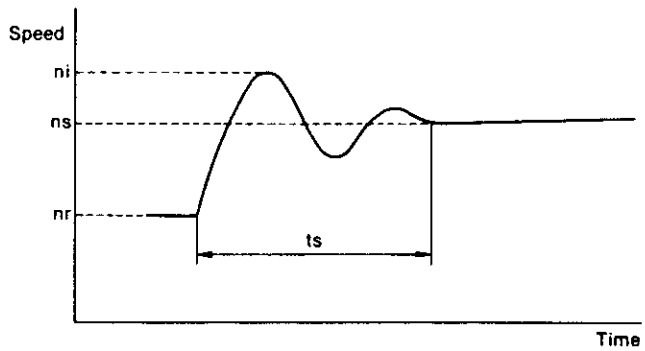
ni: Instant maximum (minimum) speed:
The maximum or minimum engine speed which is momentarily reached immediately after the load has been suddenly changed from the rated load to another load or from an arbitrary load to the rated load.

ns: Stabilized speed:
The speed which is set according to the lapse of time after the load has been changed from a rated load to another load or from an arbitrary load to the rated load.

nr: Rated speed

ts: Stabilization time:
The time it takes for engine to return to the set speed after a change.

(When load is suddenly changed from rated load to low load)



ni: Instant maximum speed (rpm)
ns: Stabilized speed (rpm)
nr: Rated speed (rpm)
ts: Stabilization time (sec.)

1·4 Disassembly

1·4.1 Disassembly

(1) Remove the injection limiter and no-load maximum speed limiter from the gear case.
(2) Remove the idle adjuster and adjuster bracket.
(3) Remove the cover at the gear case end move the governor lever 2 to match the control rack to the pulled-out position of the fuel injection pump (indicated by a slot in the gear case to show the position); then take out the fuel injecton pump.
(4) Remove the gear case from the cylinder block.
(5) Pull the thrust collar, the thrust needle bearing and the governor sleeve from the crankshaft.
(6) Loosen the end nut of crankshaft, and remove the governor weight assembly.
(7) Remove the regulator spring (main·sub.) from the regulator lever 2 and fuel control lever.
(8) Remove the circlip of the regulator lever, and remove the regulator lever and handle.
(9) Remove the governor lever shaft support bolt from the rear of the gear case, and take out the governor lever shaft assembly.
(10) Loosen the nut of engine stop lever, and pull the cam.
(11) Draw out the locking screw from the rear of the gear case, and remove the taper pin for setting the return spring.
(12) Remove the engine stop lever and the spring.

1·4.2 Reassembly and precautions

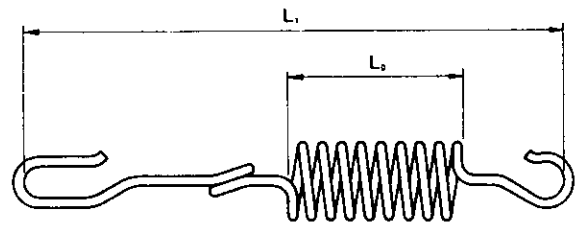
Reassemble in the reverse order of disassembly, paying special attention to the folowing items.
(1) Check the governor weight movement.
(2) Check for the movement of the governor sleeve sliding on the crankshaft.
(3) Since a common taper pin hole is drilled in the governor lever shaft and governor levers 1 and 2, they must be replaced as an ass'y.
(4) Since the movement and play of the governor lever have a direct effect on the governor's performance, they must be carefully checked.

1·5 Parts inspection and replacement

1·5.1 Regulator spring

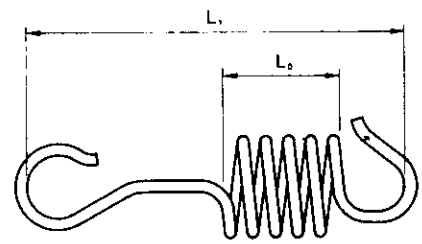
(1) Inspect the spring for coil damage, corrosion and hook deformation, and replace if faulty.
(2) Measure the spring's dimensions and spring constant. Since the spring constant determines the governor's performance, it must be carefully checked.

Spring specifications
1) Regulator spring (main)



		2GMFY, 3GMFY
Wire diameter		ø2.3mm (0.0906in.)
Coil outside diameter		ø18.3mm (0.7205in.)
Number of coils		7.5
Spring constant		0.922 kg/mm (0.516 lb/in.)
Free length	L_0	20mm (0.7874in.)
	L_1	78mm (3.0709in.)

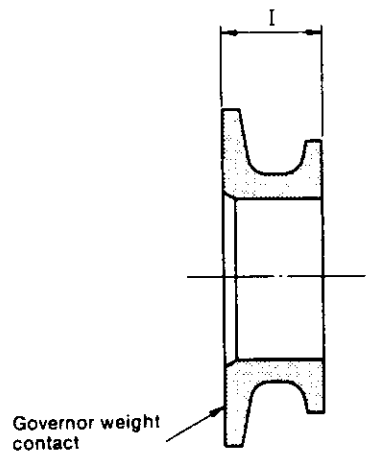
2) Regulator spring (sub)



		2GMFY, 3GMFY
Wire diameter		ø1.2mm (0.0472in.)
Coil outside diameter		ø9.2mm (0.3622in.)
Number of coils		7
Spring constant		0.578 kg/mm (0.3237 lb/in.)
Free length	L_0	10mm (0.3937in.)
	L_1	23mm (0.9055in.)

1-5.2 Sleeve

(1) Slide the sleeve on the crankshaft to check that it slides smoothly.
(2) Measure the clearance between the crankshaft and the inside of the sleeve, check the contact between the governor weight.



mm (in.)

	Maintenance standard	Clearance when assembled	Maximum allowable clearance	Wear limit
Crankshaft outside diameter	$\varnothing 25^{-0.007}_{-0.028}$ (0.9831 ~ 0.9840)	0.06 ~ 0.111 (0.0024 ~ 0.0044)	0.2 (0.0079)	—
Governor sleeve inside diameter	$\varnothing 25^{+0.083}_{+0.053}$ (0.9863 ~ 0.9875)			—
Governor sleeve overall length (ℓ)	15 ±0.1 (0.5866 ~ 0.5945)	—		14.8 (0.5827)

1-5.3 Thrust collar

Check the contact between the governor lever 1 and replace the collar when wear exceeds the wear limit.

mm(in.)

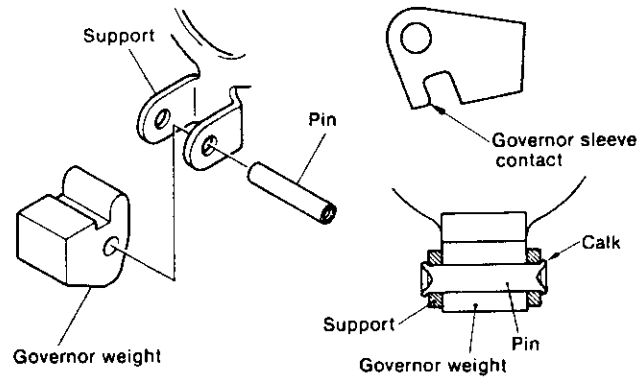
	Maintenance standard	Wear limit
Thrust collar thickness	3 (0.1181)	0.1 (0.0394)

1-5.4 Thrust needle bearing

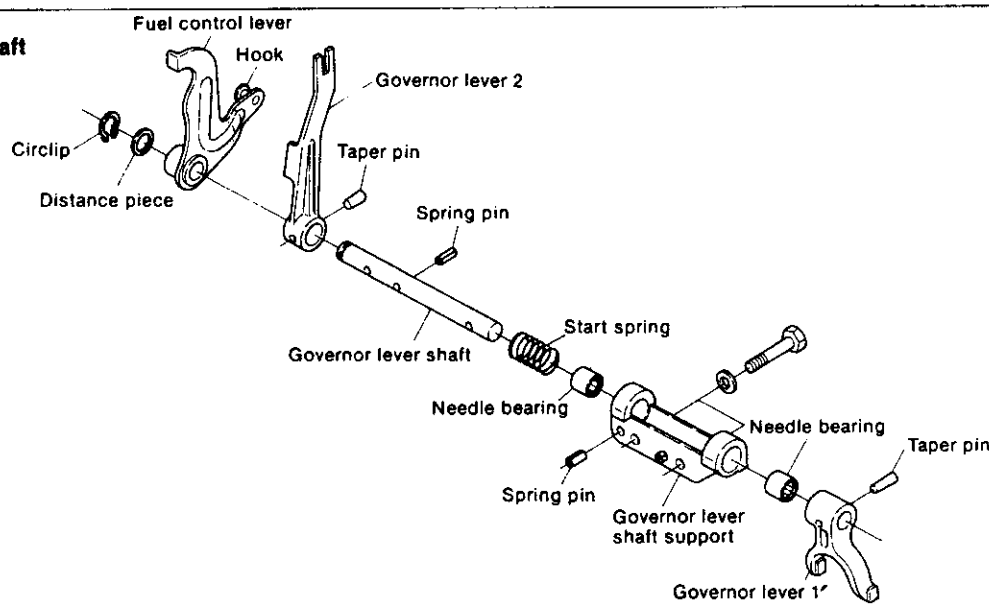
Replace the bearing when wear exceeds the specified limit.

1-5.5 Governor weight

(1) Check contact with the sleeve and for wear.

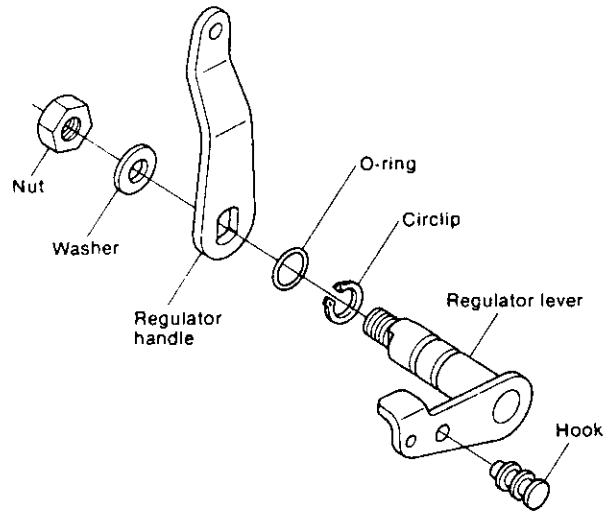


1-5.6 Governor lever shaft



(1) Replace the governor lever shaft if there is play between the shaft and needle bearing, play when the lever is moved, or if the shaft does not move smoothly.
(2) Repair or replace the shaft if there is play between lever 1, lever 2, fuel control lever or support and the shaft, or if the taper pin is loose.
(3) Inspect the contact between the governor lever 1 and the governor sleeve, replace it if it is too damaged.

1-5.7 Regulator lever and handle



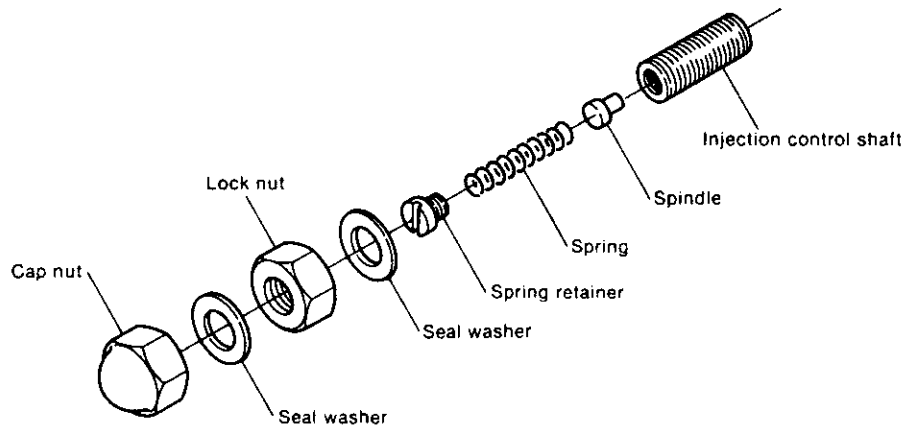
(1) Check for play in the regulator lever and regulator handle if faulty, replace them as a set.
(2) Check for O-ring damage. Replace if faulty.

2. Injection Limiter

2-1 Construction

Since surplus power is required from the standpoints of sudden overloads and durability, the engine is equipped with an injection control shaft that limits the amount of fuel injected into the precombustion chamber to a fixed amount. Moreover, since the injection control spring (torque spring) affects engine performance by adjusting engine torque, Yanmar selected the best position for operating conditions.

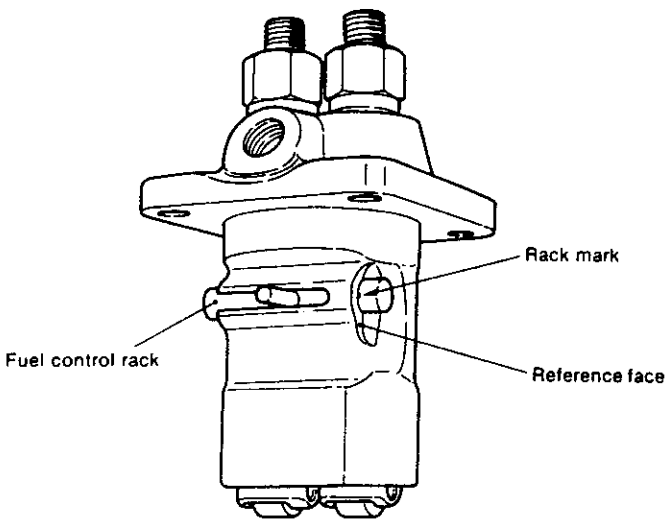
Pay close attention when handling the sealed-wire.
If the engine does not accelerate smoothly (i.e. the speed is not well controlled), turn the limiter slightly counter-clockwise.
NOTE: If it is turned back too much, it will produce exhaust smoke.



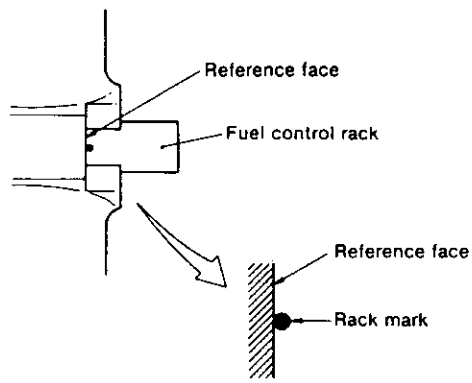
2-2 Inspection

(1) Hold the end of the spindle, and check it for smooth movement.
(2) Replace the spring if it is damaged, corroded or permanently strained.

2-3 Adjustment



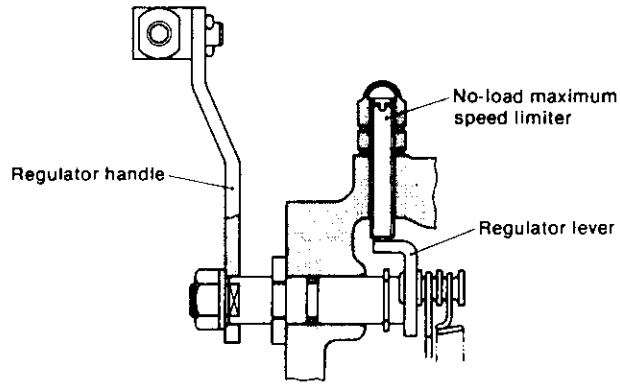
(1) Set the governor lever to the free position and remove the injection pump adjustment cover.
(2) Remove the injection control shaft cap nut, loosen the hexagonal lock nut, and loosen the injection control shaft (so that the spring inside the injection control shaft is disabled).
(3) Move governor lever 2 slowly to the left until the rack and injection control shaft contact lightly.
(4) Set the governor lever to the free position and push the rack by slowly turning the injection control shaft clockwise.
(5) Align the center mark of the rack with the reference face.
(6) Lock the injection control shaft with the hexagonal nut and cap nut.



3. No-Load Maximum Speed Limiter

3-1 Construction

A stopper is installed on the regulator lever so that the engine speed at no-load does not exceed a fixed speed. The fuel control rack is stopped when the regulator lever contacts the stopper.

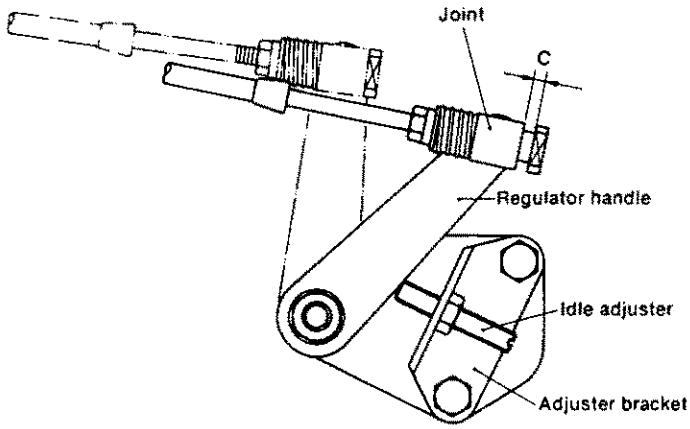


3-2 Handling precautions

The no-load maximum speed is adjusted during bench testing at the factory, and is locked with wire and sealed with lead. Care must be taken to keep the seal from being accidentally broken.

4. Idling Adjuster

When controlling the speed with the push-pull remote control, the idling adjustor operates so that the regulator handle does not move beyond the idling position in order to keep the engine running.

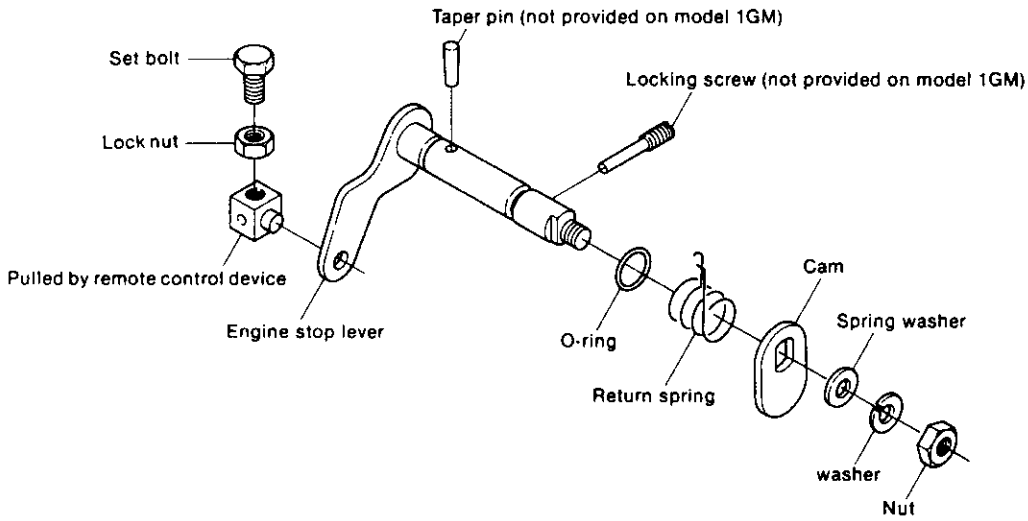


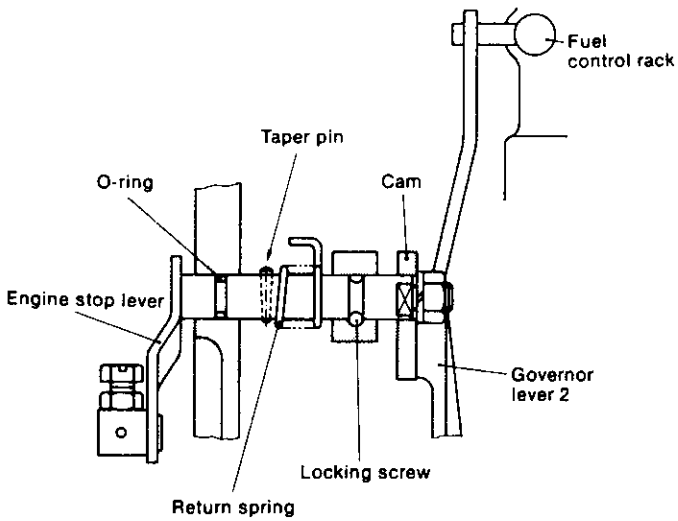
(1) When the control lever is in the neutral position, set the push-pull cable so that clearance C is 1 to 3mm (0.0397 ~ 0.1181in.).
(2) Take care not to fit the joint in the wrong direction.

5. Engine Stop Lever

5-1 Construction

With this device, governor lever 2 is moved by the cam of the engine stop lever shaft, regardless of the position of the regulator lever, so as to adjust the fuel control rack and reduce the supply of fuel.
This device can be remote-controlled.





5-2 Inspection

(1) Check for play in the Cam or Taper pin and the engine stop lever. If faulty, replace them as a set.
(2) Check for O-ring damage. Replace if faulty.
(3) Inspect the spring for coil damage and corrosion and replace if faulty.
(4) Inspect the contact between the governor lever 2 and the dam, replace the cam if it is too damaged.

CHAPTER 5

LUBRICATION SYSTEM

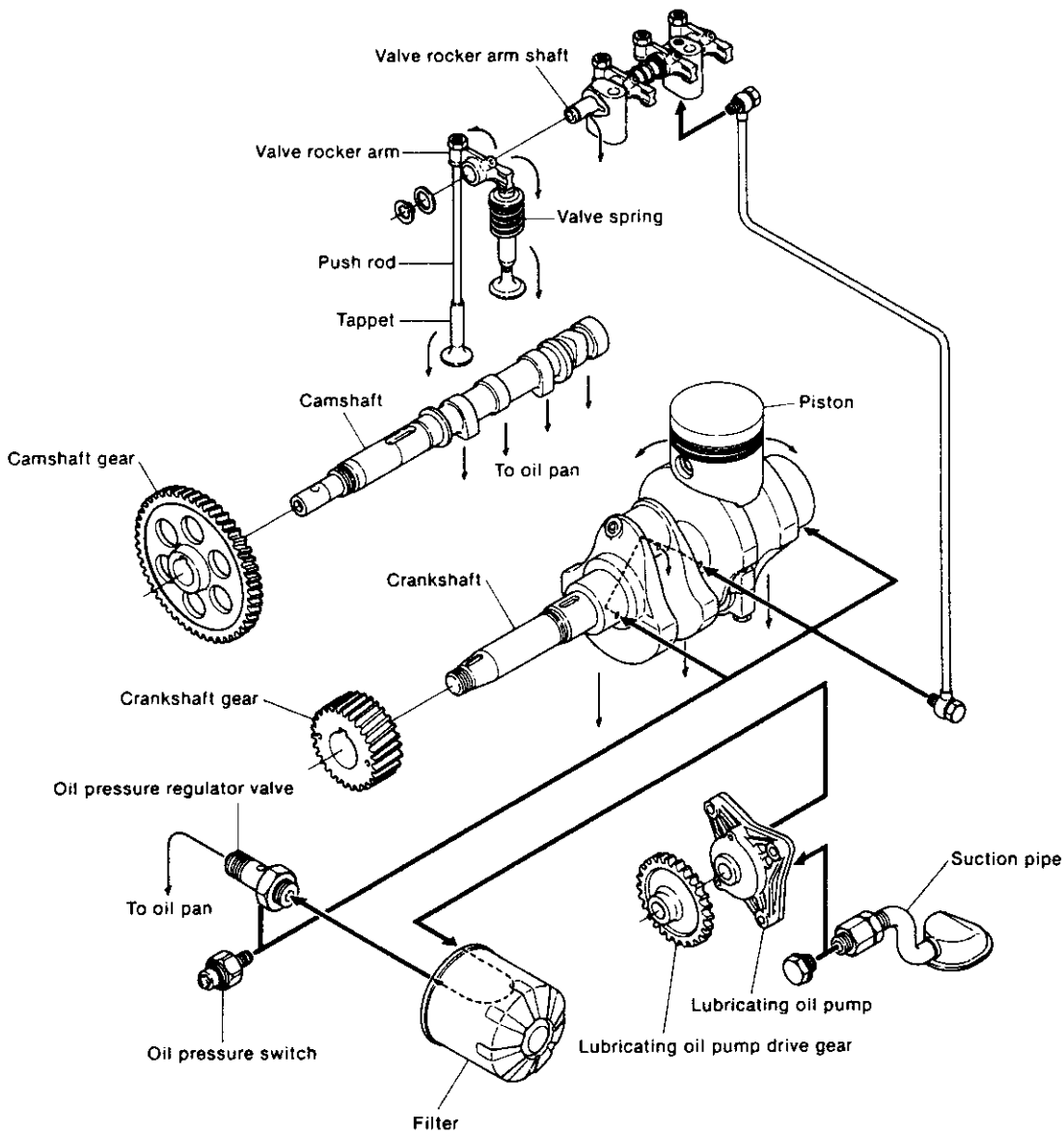
1. Lubrication System 5-1
2. Oil Pump 5-5
3. Oil Filter 5-9
4. Oil Pressure Regulator Valve 5-12
5. Oil Pressure Measurement 5-14

1. Lubrication System

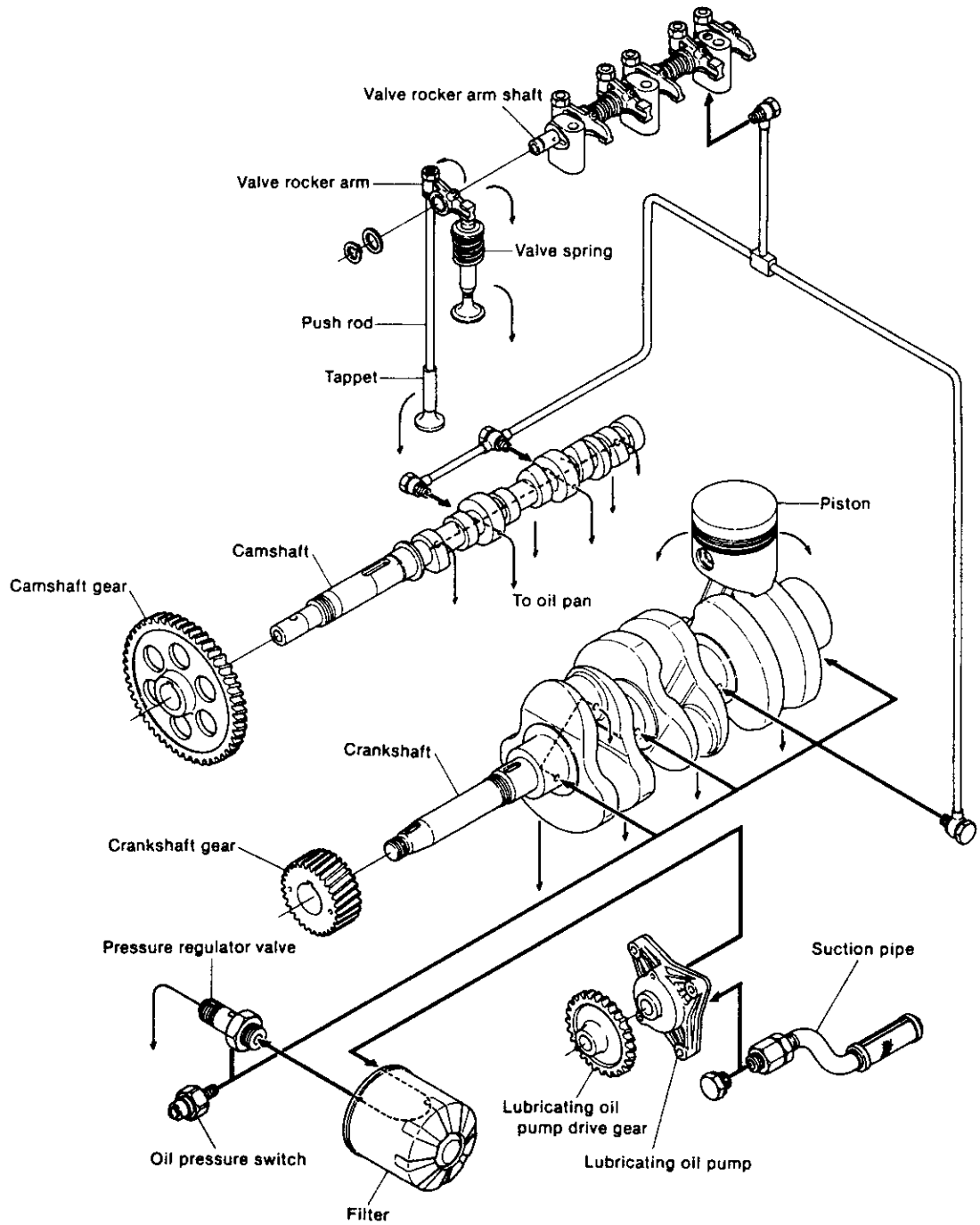
Engine parts are lubricated by a trochoid pump forced lubrication system. To keep the engine exterior uncluttered and to eliminate vibration damage to piping, exterior piping has been minimized by transporting the lubricating oil through passages drilled in the cylinders and timing gear case.

1-2 Lubrication oil passage of model 2GMFY

The lubricating oil supplied from the oil filter in the rocker arm cover is collected in the oil pan at the bottom of the cylinder block through the tappet holes.
The lubricating oil is drawn back up through the lubricating oil suction pipe by the trochoid pump and fed to the oil filter, where impurities are filtered out. Then it is adjusted to the prescribed pressure by the oil pressure regulating valve and sent to the main bearing.
The lubricating oil sent to the gear side main bearing flows in two paths: one from the main bearing to lubricate the crank pin through the hole drilled through the crankshaft.
The lubricating oil sent to the flywheel side main bearing also flows in two paths: one from the main bearing to lubricate the crank pin through the hole drilled through the crankshaft, and the other to the rocker arm shaft through the hole drilled through the cylinders and cylinder head.
From the rocker arm shaft, the lubricating oil flows through the small hole in the rocker arm to lubricate the push rods and part of the valve head.
The oil that has dropped to the push rod chamber from the rocker arm chamber lubricates the tappets, cam and cam bearing, and returns to the oil pan.
The pistons, piston pins and contact faces of the cylinder liners are splash lubricated by the oil that has lubricated the crank pin. Moreover, an oil pressure switch is provided in the lubricating system to monitor normal circulation and pressure of the lubricating oil. When the lubricating oil pressure drops 0.5kgf/cm² (7.114 lb/in.²), the oil pressure switch illuminates the oil pressure lamp on the instrument panel to notify the operator.



1-3 Lubrication oil passage of model 3GMFY



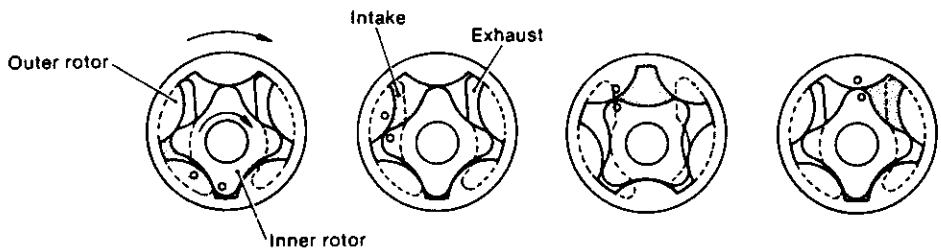
1-4 Table of capacity for lubricating oil system

			2GMFY	3GMFY
Lubricating oil pump	Pump speed	rpm	3600	
	Discharge volume	ℓ/min ℓ/h	12.5 760	
	Discharge pressure	kgf/cm² (lb/in.²)	3.5 ±0.5 (42.67 ~ 56.89)	
Lubricating oil filter	Filter capacity			
	Discharge pressure	kgf/cm² (lb/in.²)	1 (14.22)	
Oil pressure regulator valve	Standard pressure	kgf/cm² (lb/in.²)	3.5 ±0.5 (42.67 ~ 56.89)	
	Full open pressure (Max)	kgf/cm² (lb/in.²)	4 (56.89)	
Lubricating oil pressure alarm switch	ON	kgf/cm² (lb/in.²)	0.2 ±0.1 (1.422 ~ 4.266)	
Lubricating oil tank	Crankcase oil capacity, Total (effective)	ℓ	2.0 (1.3)	2.7 (1.8)

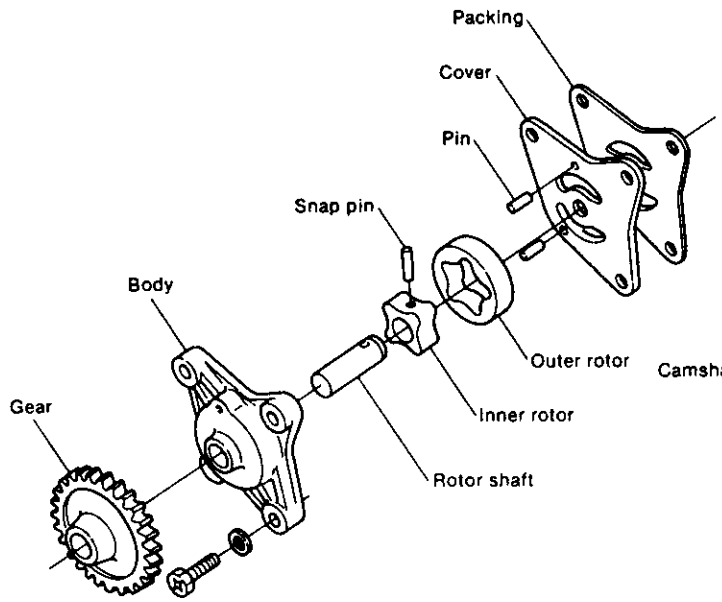
2. Oil Pump

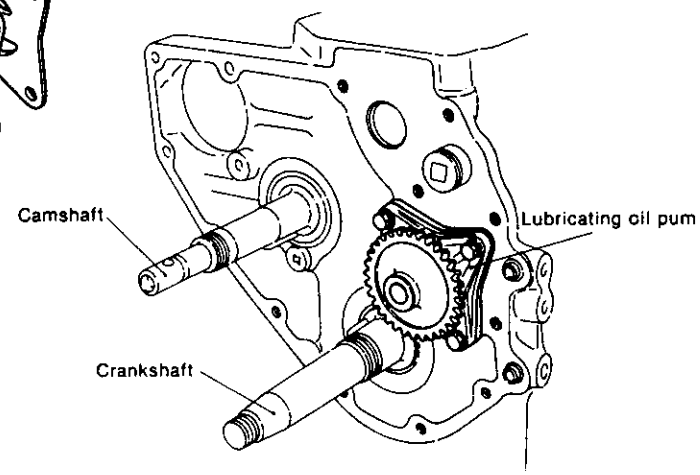
2-1 Construction

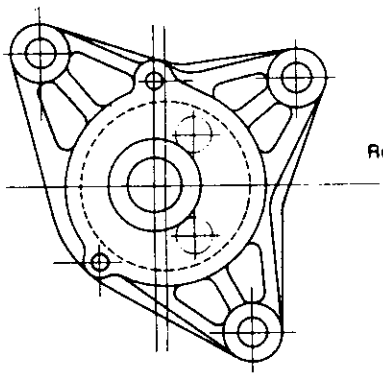
The oil pump is a compact, low pressure variation trochoid pump comprising a trochoid curve inner rotor and outer rotor. Pumping pressure is provided by the change in volume between the two rotors caused by rotation of the rotor shaft.

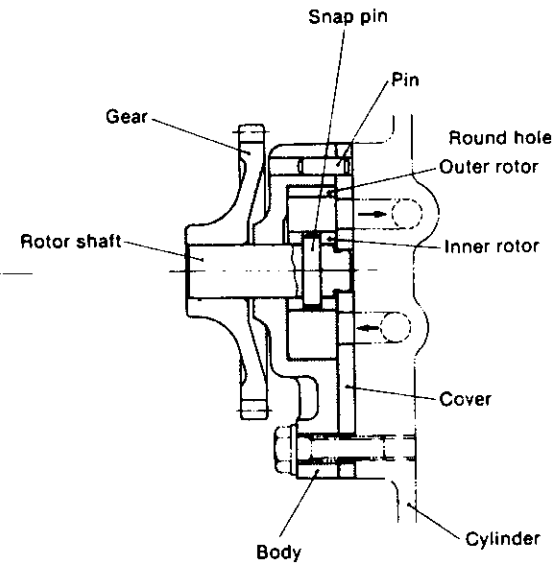


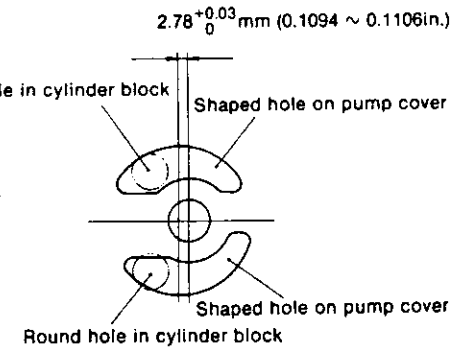
The lubricating oil pump is installed on the cylinder body at the timing gear case end, and its rotor shaft gear is driven by the crankshaft gear.
The lubricating oil is drawn in and discharged through drilled holes in the cylinder body.









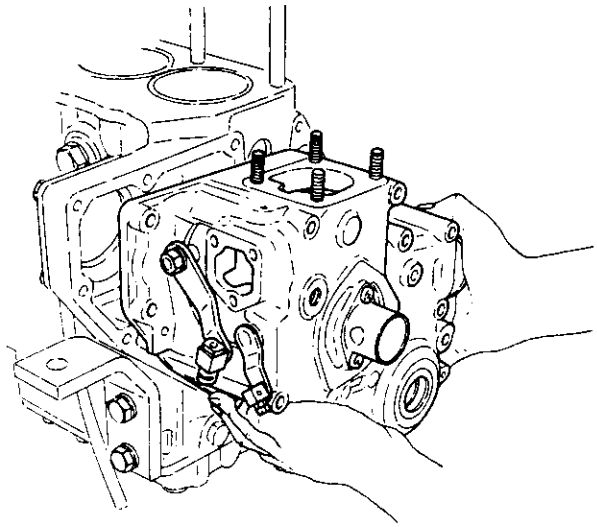

$2.78^{+0.03}_{0}$mm (0.1094 ~ 0.1106in.)
Round hole in cylinder block
Shaped hole on pump cover
Shaped hole on pump cover
Round hole in cylinder block

Specifications of lubrication oil pump

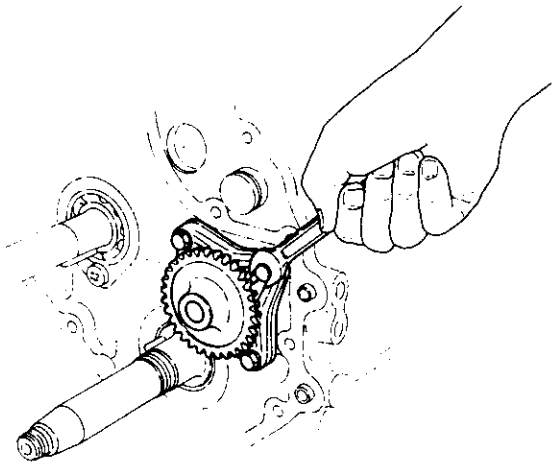
Engine speed	3600 rpm
Pump speed	3600 rpm
Discharge volume	12.5 ℓ/min 760 ℓ/h
Discharge pressure	3.5 ±0.5 kgf/cm² (42.67 ~ 56.89 lb/in.²)

2-2 Disassembly

(1) Remove the timing gear case.



(2) Remove the lubricating oil pump driving gear and pump assembly.



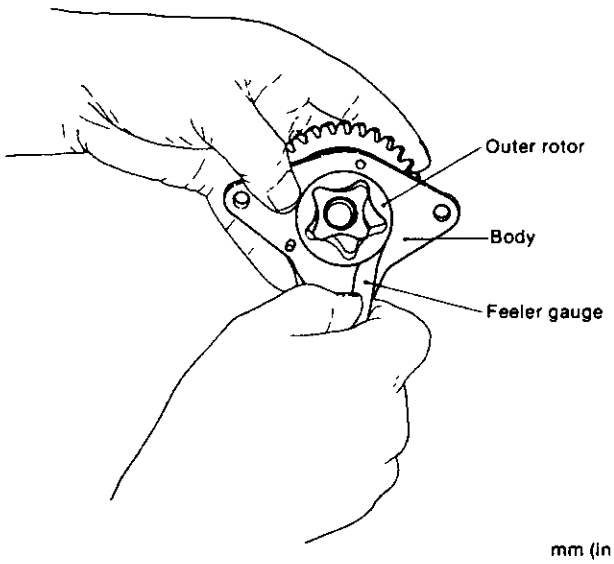
NOTE: Do not separate the lubricating pump gear from the rotor shaft. If removed, it cannot be used again. When any part is unusable, replace it as a complete assembly.

2-3 Inspection

When the discharge pressure of the oil pump is extremely low, check the oil level. If it is within the prescribed range, the oil pump must be inspected.

(1) Outer rotor and pump body clearance

Measure the clearance by inserting a feeler gauge between the outside of the outer rotor and the pump body casing. If the clearance exceeds the wear limit, replace the outer rotor and pump body as a set.

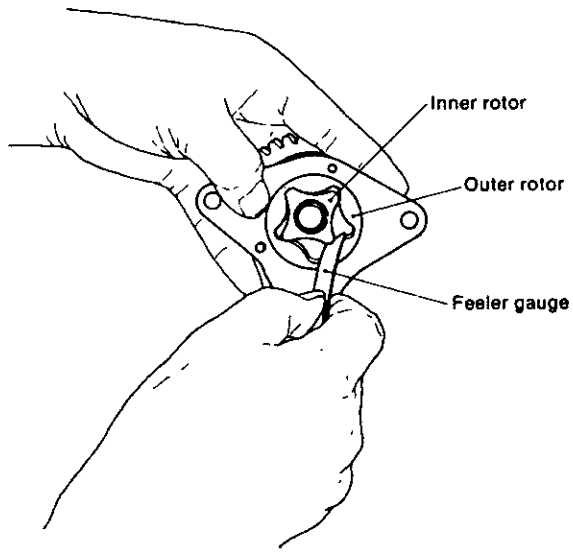


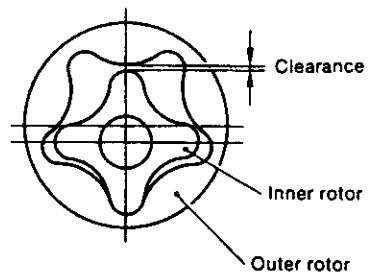
mm (in.)

Maintenance standard	0.050 ~ 0.105 (0.00197 ~ 0.00413)
Wear limit	0.15 (0.00591)

(2) Outer rotor and inner rotor clearance

Fit one of the teeth of the inner rotor to one of the grooves of the outer rotor and measure the clearance at the point where the teeth of both rotors are aligned. Replace the inner rotor and outer rotor ass'y if the wear limit is exceeded.





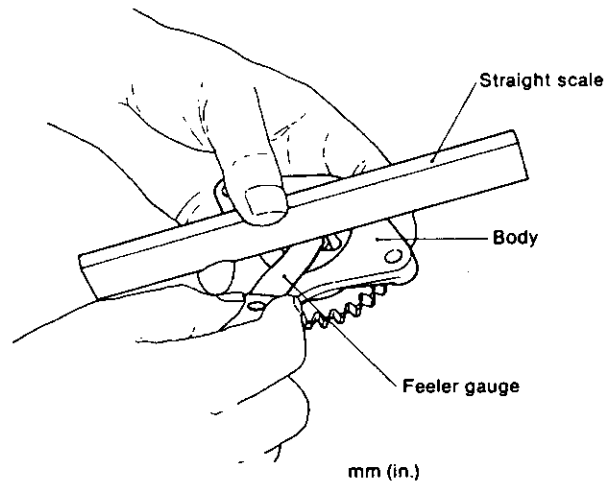
mm (in.)

Maintenance standard	0.050 ~ 0.105 (0.00197 ~ 0.00413)
Wear limit	0.15 (0.00591)

(3) Pump body and inner rotor, outer rotor side clearance

Install the inner rotor and outer rotor into the pump body casing so that they fit snugly.

Check the clearance by placing a ruler against the end of the body and inserting a feeler gauge between the ruler and the end of the rotor. Replace as a set if the wear limit is exceeded.



mm (in.)

	2GMFY, 3GMFY
Maintenance standard	0.03 ~ 0.07 (0.0012 ~ 0.0031)
Wear limit	0.13 (0.0051)

(4) Rotor shaft and body clearance

Measure the outside diameter of the rotor shaft and the inside diameter of the body shaft hole, and replace the rotor shaft and body as an ass'y if the clearance exceeds the wear limit.

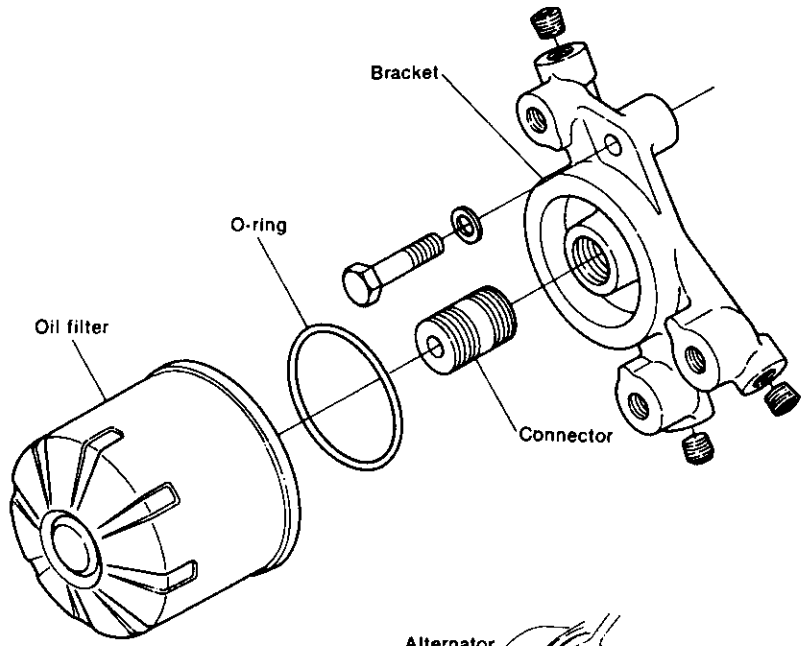
mm (in.)

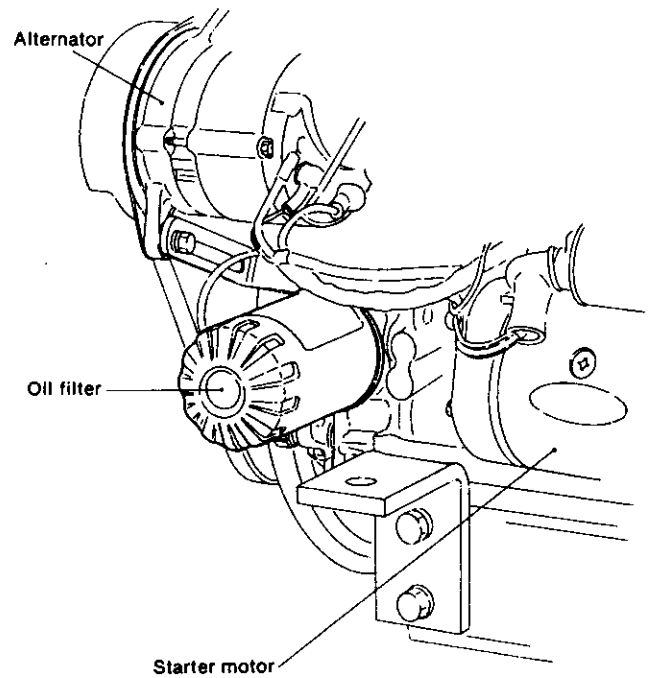
	Maintenance standard	Clearance when assembled	Maximum allowable clearance
Rotor shaft outside diameter	ø14 (0.5512)	0.015~0.050 (0.0006~0.0020)	0.2 (0.0079)
Rotor shaft hole inside diameter	ø14 (0.5512)		

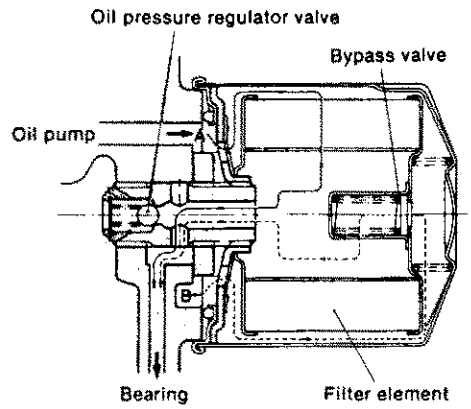
3. Oil Filter

3-1 Construction

The oil filter removes the dirt and metal particles from the lubricating oil to minimize wear of moving parts. The construction of the oil filter is shown below.
The lubricating oil from the oil pump is passed through the filter paper and distributed to each part as shown by arrow A in the figure.
After extended use, the filter paper will become clogged and its filter performance will drop. When the pressure loss caused by the filter paper exceeds 1 kgf/cm² (14.22 lb/in.²), the bypass valve inside the filter opens and the lubricating oil is sent to each part automatically as an emergency measure, without passing through the filter, as shown by arrow B.
The oil filter is located at the fitted position of the oil pressure regulator valve on the side surface of the gear case together with the oil pressure valve. The oil pressure regulator valve is installed separately on the end surface of the cylinder, in the gear case.



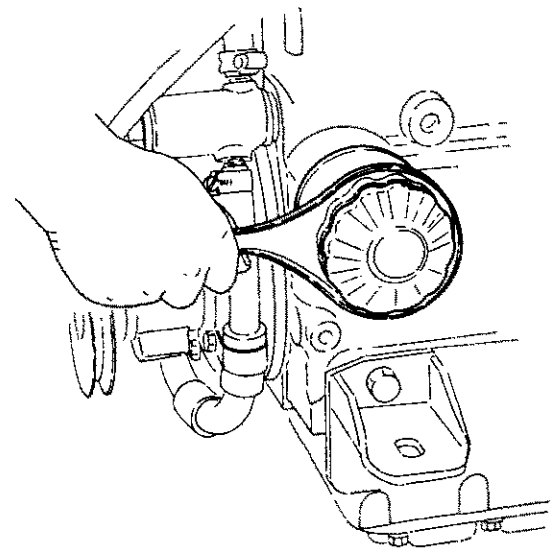


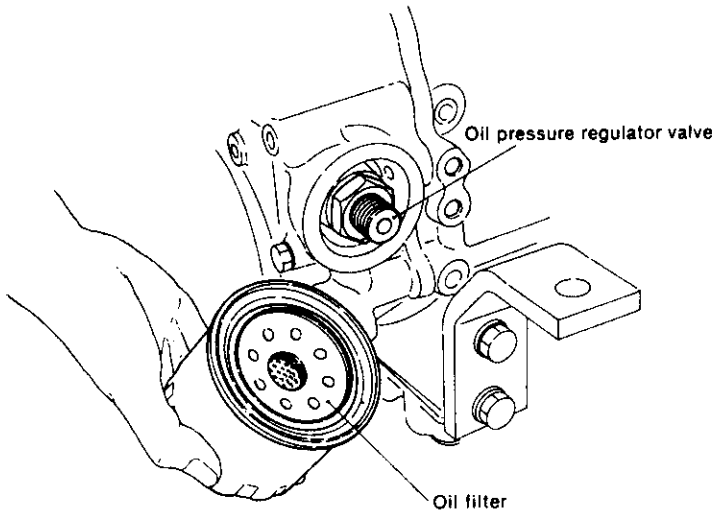


3-2 Replacement

When the oil filter has been used for an extended period, the filter paper will become clogged, unfiltered lubricating oil will be sent directly to each part from the bypass circuit, and wear of moving parts will be accelerated. Therefore, it is important that the filter be periodically replaced.
Because this oil filter is a cartridge type, it is replaced as a complete unit.

Oil filter replacement period	Every 300 hours of engine operation





3-2.1 Replacing the oil filter

(1) Clean the oil filter mounting face on the cylinder block.
(2) Before installing the new filter, coat the rubber packing with a thin coat of lubricating oil.
(3) Turn the filter gently until it contacts the rubber packing of the seal surface, then tighten another 2/3 turn.
(4) After installation, run the engine and check the packing face for oil leakage.

3-2.2 In case of oil leakage

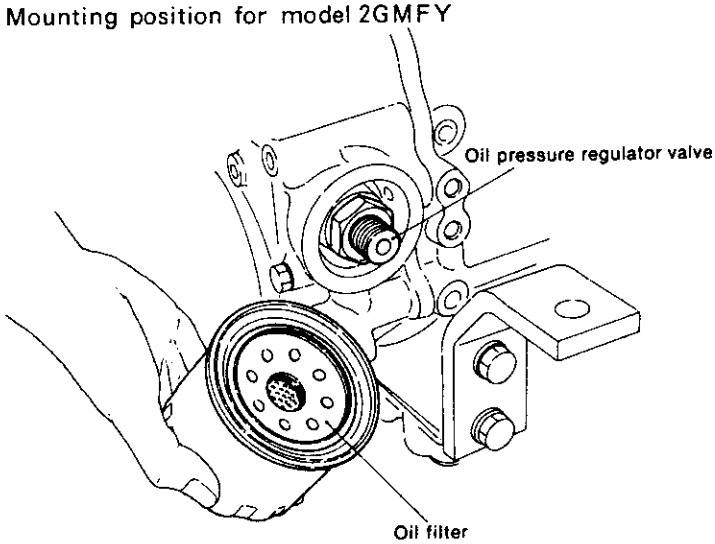
If there is oil leakage, remove the oil filter and replace the packing. At the same time, inspect the cylinder block mounting face and repair the face with an oil stone if it is scored.

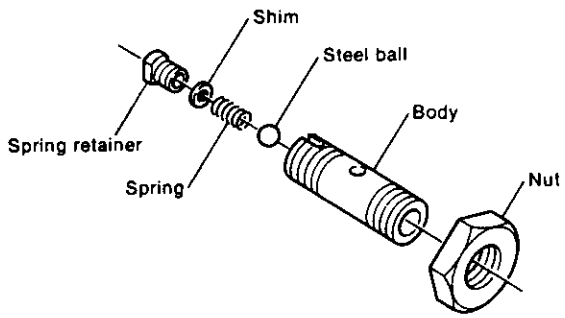
4. Oil Pressure Regulator Valve

4-1 Construction

The oil pressure regulator valve serves to adjust the pressure of the lubricating oil to the prescribed pressure during operation. When the pressure of the lubricating oil from the oil filter exceeds the force of the spring, the metal ball is pushed away from the valve seat and the lubricating oil flows to the oil pan through the gap between the ball and seat. The spring's force is adjusted with a shim.
The regulator valve is located in the mounting position of the lubricating oil filter at the timing gear case.

Mounting position for model 2GMFY

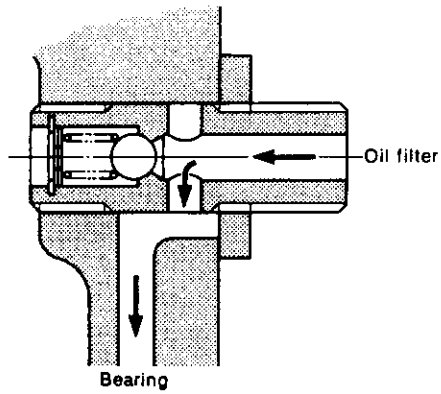




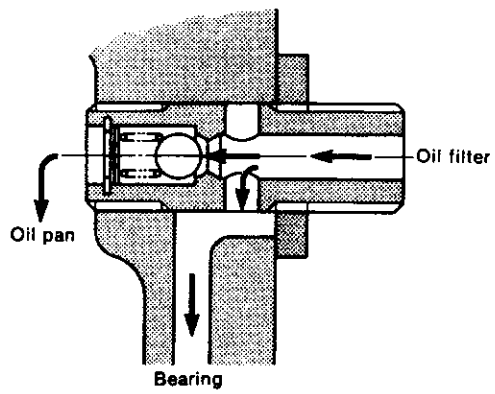
Specifications

Standard pressure	3.5 ±0.5 kgf/cm² (42.67 ~ 56.89 lb/in.²)

As the lubricating oil pressure regulator valve has been calked during manufacture so that it cannot be dismantled, replace it as a unit if any replacement becomes necessary.



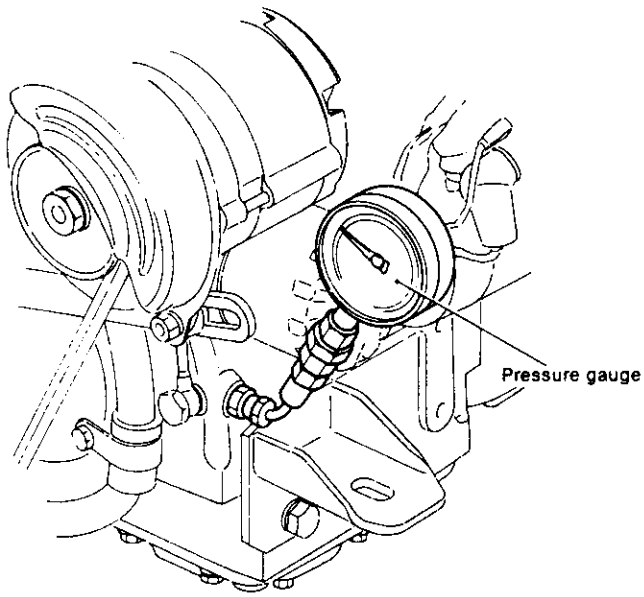
When the pressure is lower that the regulated pessure



When the pressure is higher that the regulated pressure

5. Oil Pressure Measurement

The lubricating oil pressure is monitored by a pilot lamp, but it must also be measured using a pressure gauge. Connect the oil pressure gauge to the pilot lamp unit for primary pressure and to the lubricating oil pipe connector for secondary pressure, as shown in figure.
Secondary oil pressure is especially important. Idle the engine at medium speed when measuring the oil pressure. Also check whether the oil pressure rises smoothly and to the standard value.



kgf/cm² (lb/in.²)

	850 rpm	3600 rpm
Secondary pressure standard value	0.5 (7.11)	3.5 ±0.5 (42.67~56.89)

If the oil pressure is lower than the standard value, probable causes are:
(1) Clearance of lubricated bearings in the lubricating oil circuit is too large (Shaft or bearing is worn).
(2) Excessive oil escaping from rocker arm support.
Therefore, inspection and repair of the bearings and rocker arm support are required.

CHAPTER 6

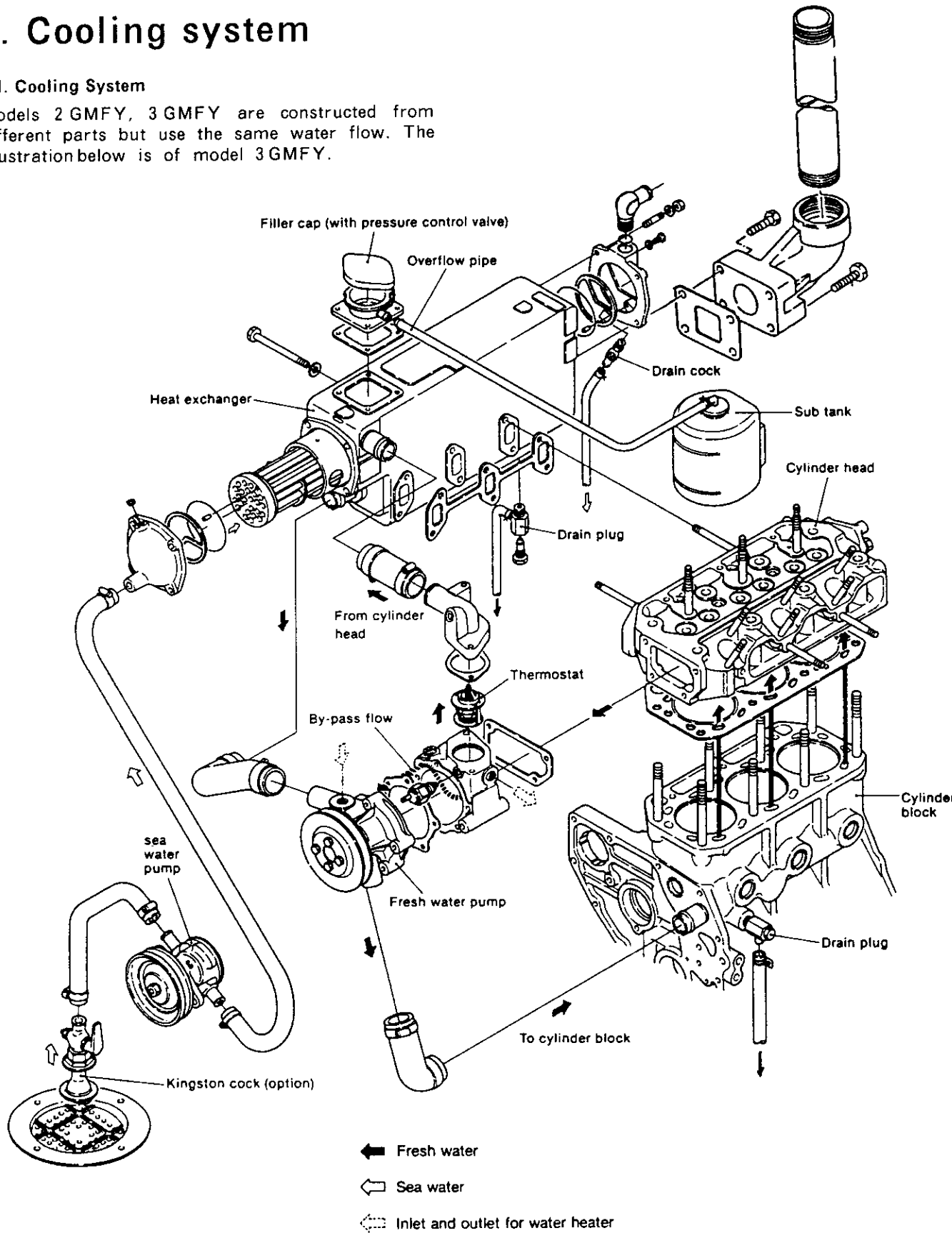
COOLING SYSTEM

1. Coolling System 6-1
2. Water Pump 6-3
3. Heat Exchanger 6-11
4. Filler Cap and Subtank 6-15
5. Thermostat 6-17
6. Coolling Water Temperature Switch 6-20
7. Precautions 6-21
8. Kingston Cock(Optional) 6-23
9. Bilge Pump and Bilge Strainer(Optional) 6-24

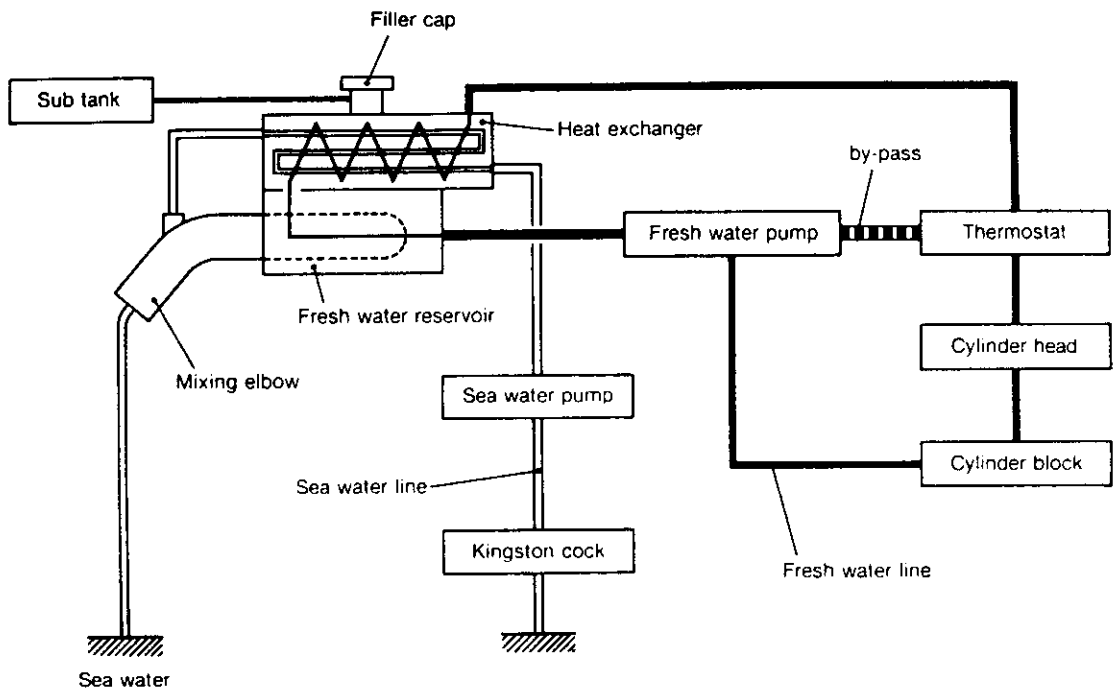
1. Cooling system

1-1. Cooling System

Models 2 GMFY, 3 GMFY are constructed from different parts but use the same water flow. The illustration below is of model 3 GMFY.



1-2. Cooling system diagram



1-3. Cooling system configuration

With fresh water cooled engines, fresh water from the heat exchanger is circulated around the cylinder block and cylinder head. The fresh water itself is cooled by sea water. The fresh water pump forces the fresh water through the cylinder block and cylinder head cooling passages and back to the heat exchanger. The fresh water is kept in constant circulation.

The thermostat is installed at the cylinder head cooling water outlet (fresh water pump mounting bracket). As the thermostat is closed while the fresh water temperature is low—directly after starting engine or when engine load is light—fresh water flows through the by-pass passage to the suction side of the fresh water pump, and circulates inside the engine without passing through the heat exchanger.

As the fresh water temperature rises the thermostat is opened and fresh water flows into the heat exchanger. The fresh water is cooled in the heat exchanger by sea water in the tube. So that the fresh water temperature is always kept at the proper degree by the thermostat.

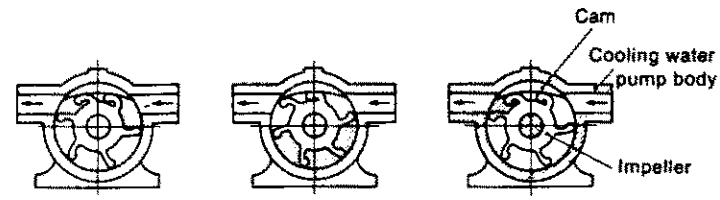
Sea water is delivered by the sea water pump and fed through tubes located inside the cooling pipe to cool the fresh water.

Sea water flows into the mixing elbow from the heat exchanger, and is discharged with the exhaust gas.

2. Water Pump

Construction and operation

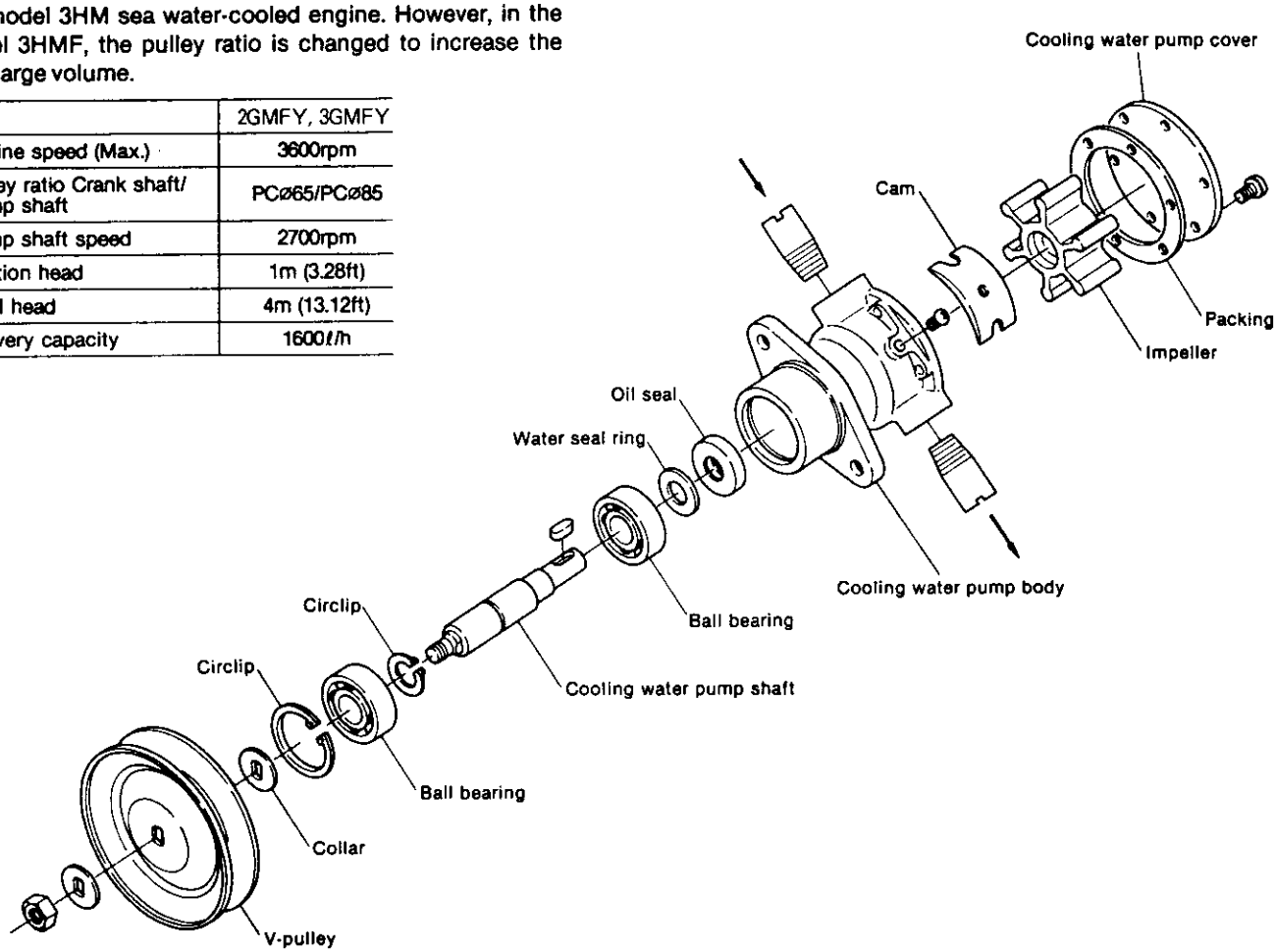
The water pump is a rubber impeller type pump. The rubber impeller, which has ample elasticity, is deformed by the offset plate inside the casing, causing the water to be discharged. This pump is ideal for small, high-speed engines.

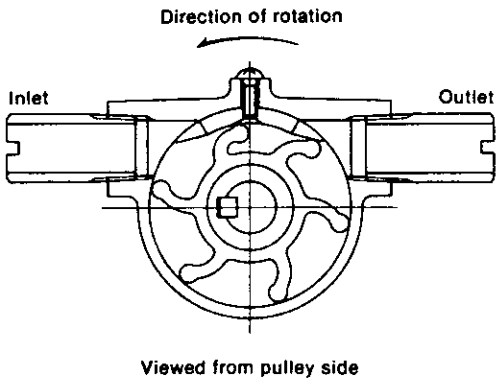


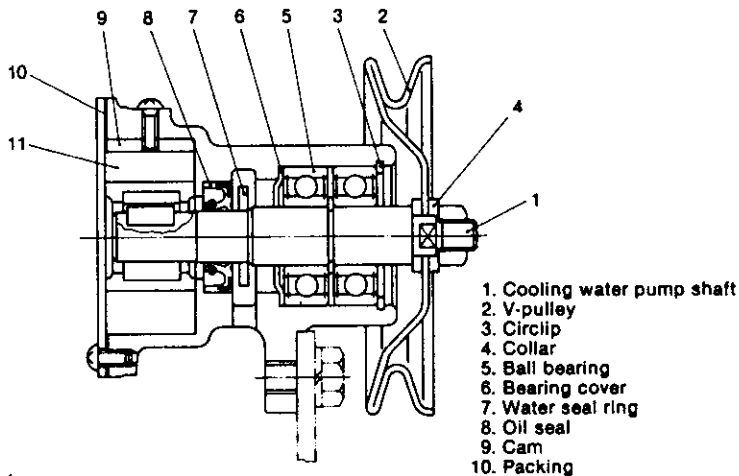
2-1. Sea Water Pump

The sea water pump used for the fresh water-cooled engine is the rubber impeller pump; it is the same type as used for the sea water-cooled engine.
The same sea water pumps are used for models 2GMF, 3GMF and 3HMF; these are also the same type as used for the model 3HM sea water-cooled engine. However, in the model 3HMF, the pulley ratio is changed to increase the discharge volume.

	2GMFY, 3GMFY
Engine speed (Max.)	3600rpm
Pulley ratio Crank shaft/ Pump shaft	PC⌀65/PC⌀85
Pump shaft speed	2700rpm
Suction head	1m (3.28ft)
Total head	4m (13.12ft)
Delivery capacity	1600ℓ/h





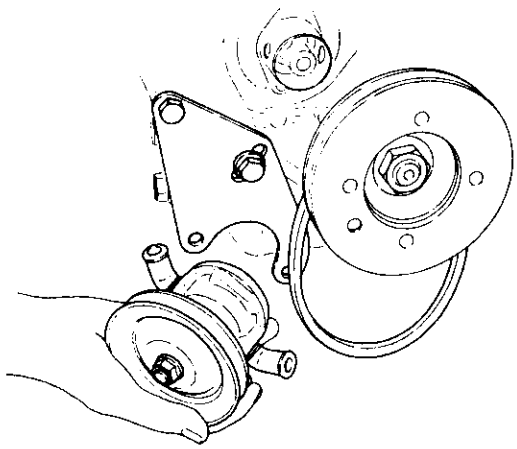


1. Cooling water pump shaft
2. V-pulley
3. Circlip
4. Collar
5. Ball bearing
6. Bearing cover
7. Water seal ring
8. Oil seal
9. Cam
10. Packing
11. Impeller

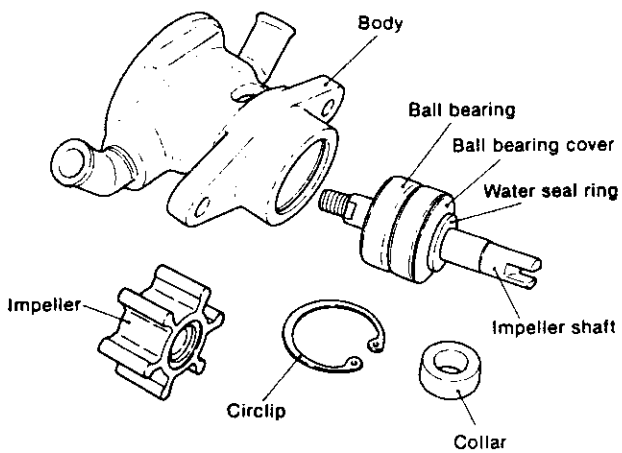
NOTE: For details on the disassembly and reassembly, handling precautions and inspection, refer to Service Manual.

Disassembly

(1) After removing the V-belt by loosening the mounting bolts of the cooling water pump bracket, remove the cooling water pump assembly.

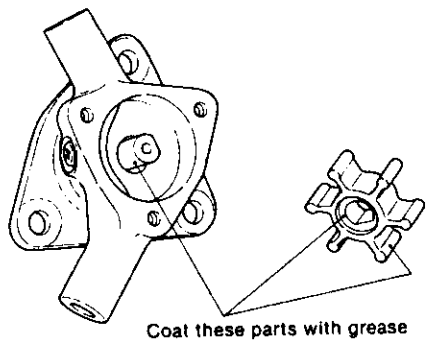


(2) Remove the cooling water pump bracket.
(3) Remove the V-pulley mounting bolt and V-pulley.
(4) Remove the cooling water pump cover fixing screws, and then remove the cooling water pump cover and packing.
(5) Pull the water pump impeller.
(6) Remove the set screw and remove the offset plate.
(7) Remove the bearing snap ring and remove the impeller shaft and bearing ass'y while tapping the impeller side of the impeller shaft lightly.
At the same time, the bearing cover and seal ring can be removed together with the impeller shaft.
(8) Pull the oil seal from the pump body.
(9) Pull the ball bearing and spacer from the impeller shaft.

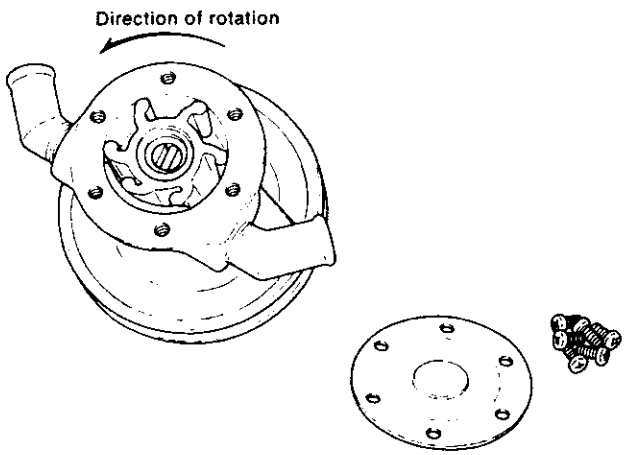


Reassembly precautions

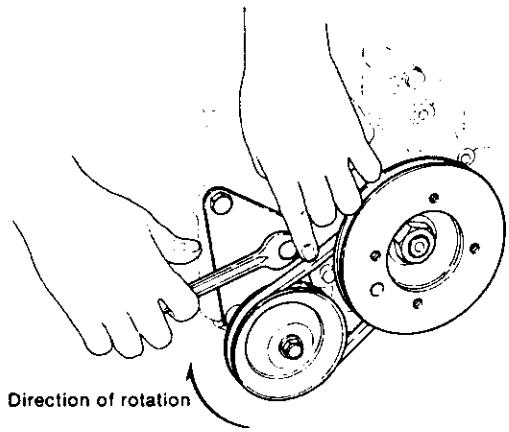
(1) Before inserting the rubber impeller into the casing, coat the sliding face, pump shaft and impeller fitting section with grease or Monton X.



(2) Be sure that the direction of curving of the impeller is correct.
The impeller is curved in the direction opposite the direction of rotation.



(3) Adjust the V-belt tension.
If the V-belt tension is slack, the discharge of the cooling water will diminish; if it is too tight, the play of the pump bearings and the wear of the wear plate will be accelerated. Adjust the tension to the specified value. Check the deflection of the V-belt by pressing it in the center with your fingers.



V-belt tension	To be 5 ~ 7mm (0.1964 ~ 0.2756in.) deflection when pushed with the thumb with a force of 10kg (22.0 lb)
Type of V-belt	M19in.
V-belt part No.	104511-78780

NOTE: Mount the belt in the direction of pump rotation.

(4) If the sliding surface of the V-belt is cracked or worn or is stained with oil, etc., replace it with a new one.

(5) Check after assembly
After assembly, attach the belt and run the engine to ascertain whether or not it provides the specified discharge.

Handling precautions

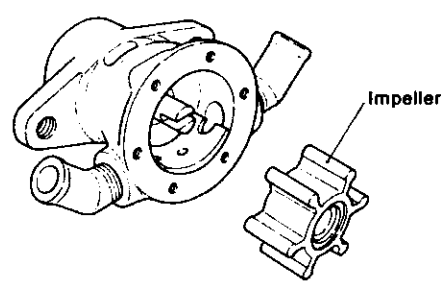
(1) Never operate the water pump dry as this will damage the rubber impeller.

(2) Always turn the engine in the correct direction of rotation as turning the engine in the opposite direction will damage the rubber impeller.

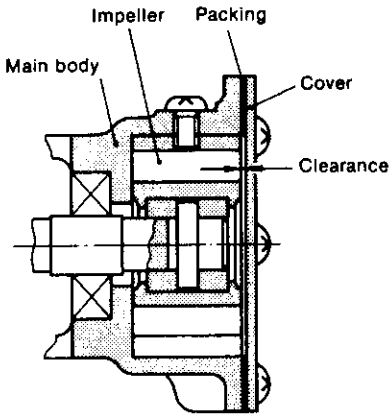
(3) Inspect the pump after every 1,500 hours of operation and replace if faulty.

Inspection

(1) Inspect the rubber impeller for fractures, cracks and other damage, and replace if faulty.



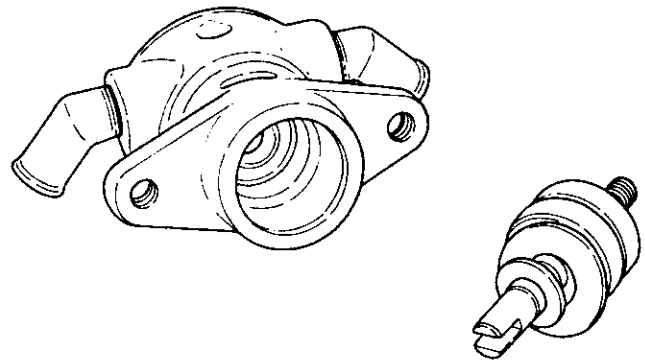
(2) Rubber impeller side wear



mm (in.)

	Maintenance standard	Clearance at assembly	Maximum allowable clearance	Wear limit
Impeller width	19 ±0.1 (0.744 ~ 0.752)	0.2 (0.0079)	0.4 (0.0157)	—
Housing width	18.9 (0.7441) (without packing) 19.2 (0.7559) (with packing)			—
Wear plate wear	—			0.2 (0.0079)

(3) Water pump impeller shaft oil seal section wear.



mm (in.)

	Maintenance standard	Wear limit
Oil seal section shaft diameter	10.0 (0.3937)	9.9 (0.3898)

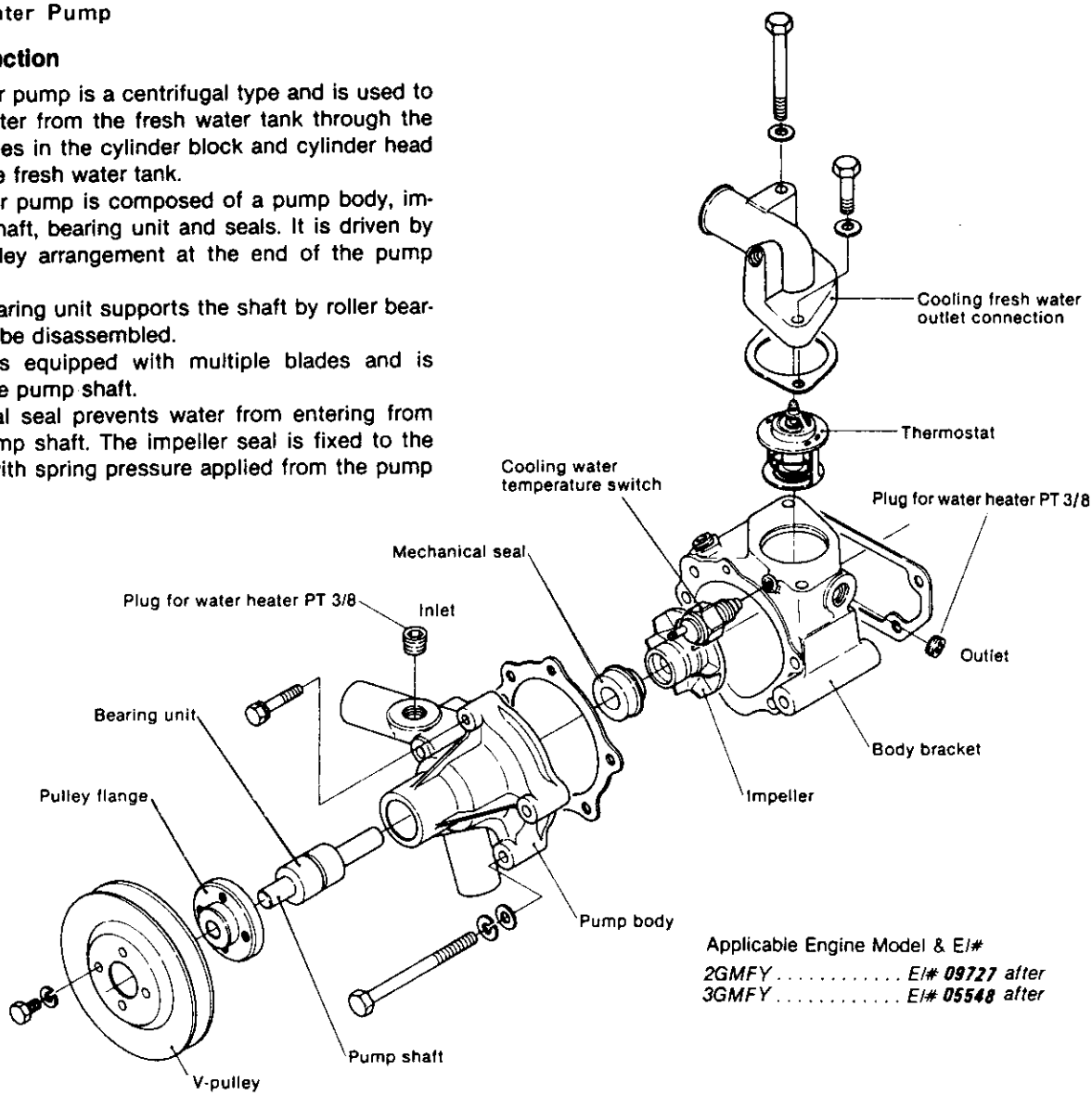
If water leakage increases while the engine is running, or if the components are found to be defective when disassembled, replace them.

(4) Inspect the bearing for play and check for seizing at the impeller shaft fitting section. Replace the bearing if there is any play.

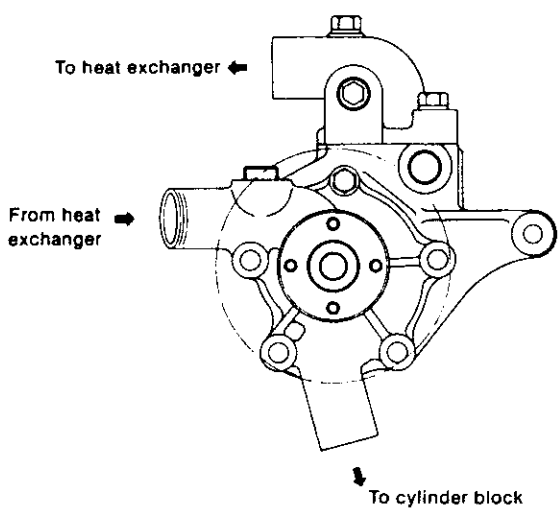
2-2. Fresh Water Pump

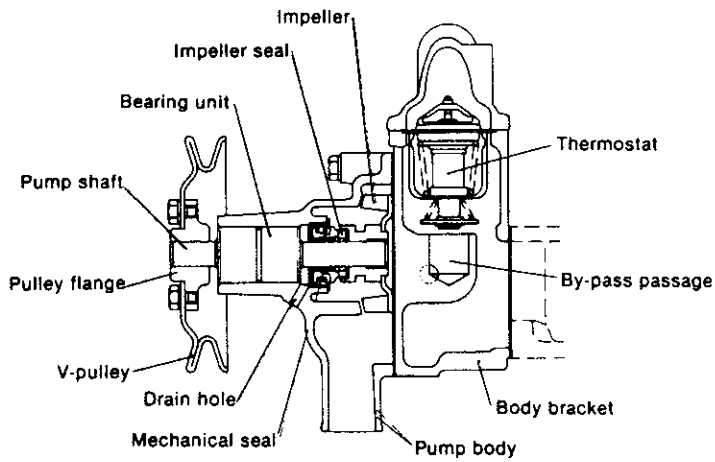
Pump construction

The fresh water pump is a centrifugal type and is used to move fresh water from the fresh water tank through the cooling passages in the cylinder block and cylinder head and back to the fresh water tank.
The fresh water pump is composed of a pump body, impeller, pump shaft, bearing unit and seals. It is driven by a belt and pulley arrangement at the end of the pump shaft.
The packed bearing unit supports the shaft by roller bearings. It cannot be disassembled.
The impeller is equipped with multiple blades and is mounted on the pump shaft.
The mechanical seal prevents water from entering from around the pump shaft. The impeller seal is fixed to the impeller side with spring pressure applied from the pump body side.



Applicable Engine Model & E/#
*2GMFY ..... E/# **09727** after*
*3GMFY ..... E/# **05548** after*



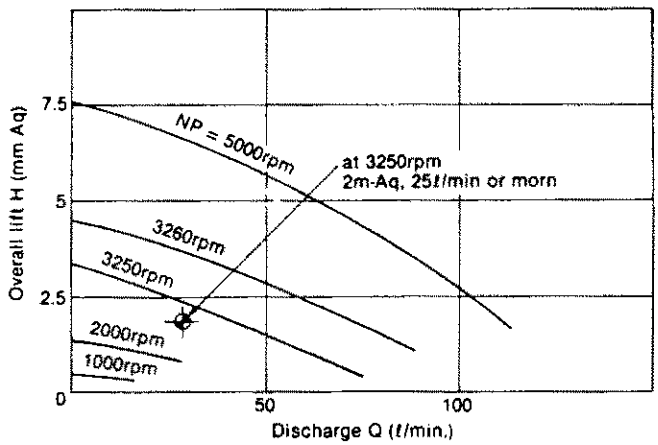


Pump capacity and characteristic

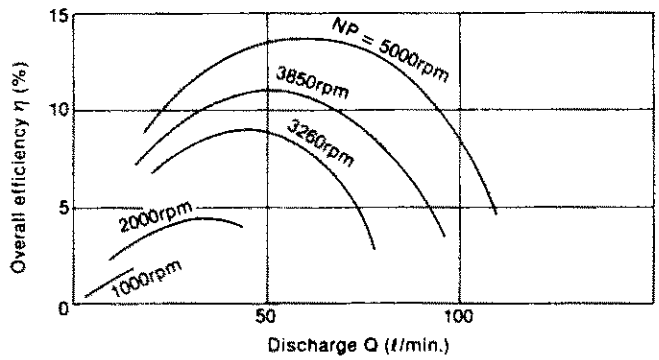
	2GMFY, 3GMFY
Crank shaft speed	3600rpm
Pulley ratio Crank shaft/ Pump shaft	PCø127/PCø103
Pump shaft speed	4400rpm
Delivery capacity	4000*l*/h
Total head	3m (9.84ft)

NOTE: The same type of fresh water pump is used for models 2GMFY, 3GMFY.

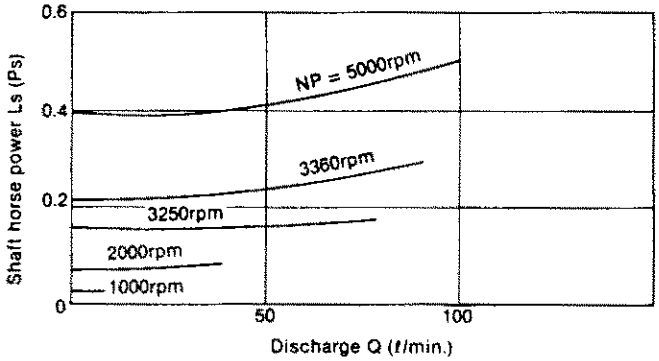
H-Q diagram Water temperature 80±2°C



η-Q diagram Water temperature 80±2°C



Ls-Q diagram Water temperature 80±2°C

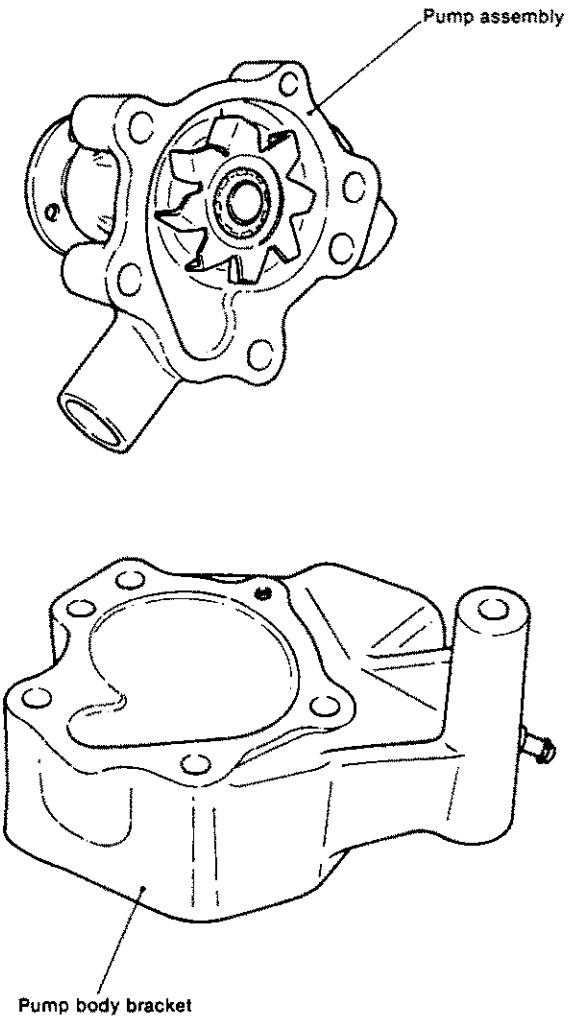


Pump disassembly

Disassembly of the fresh water pump is difficult and should not be attempted. Faulty units should be replaced. The pump assembly should not be disassembled from the pump body brackets, unless absolutely necessary.

kgf-cm (ft•lb)

Tightening torque for pump setting bolts	40—80 (2.89 ~ 5.79)

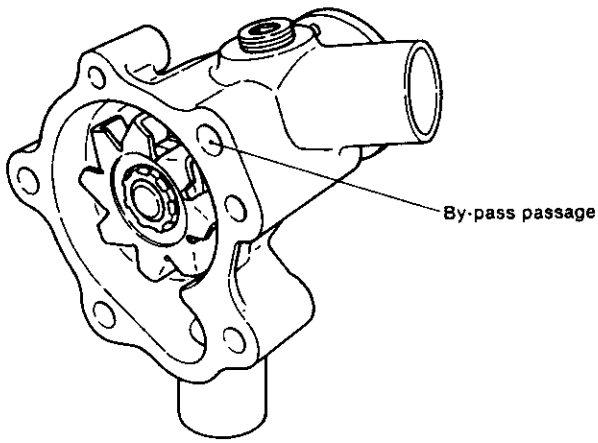


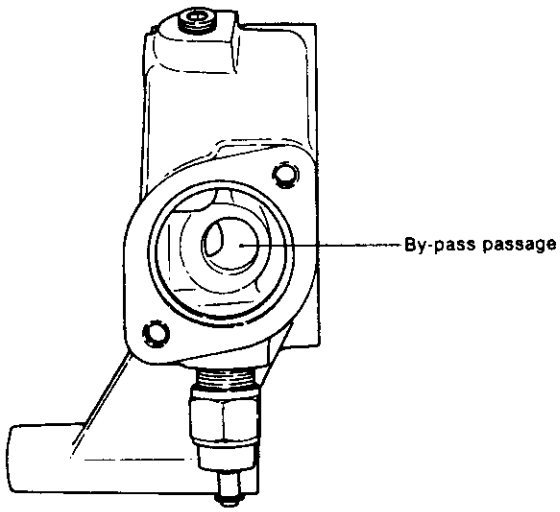
Inspection and measurement

(1) Confirm smooth rotation by rotating the impeller by hand.
When the rotation is not smooth, due to bearing play or friction, or abnormal noise is heard, replace the entire pump assembly.

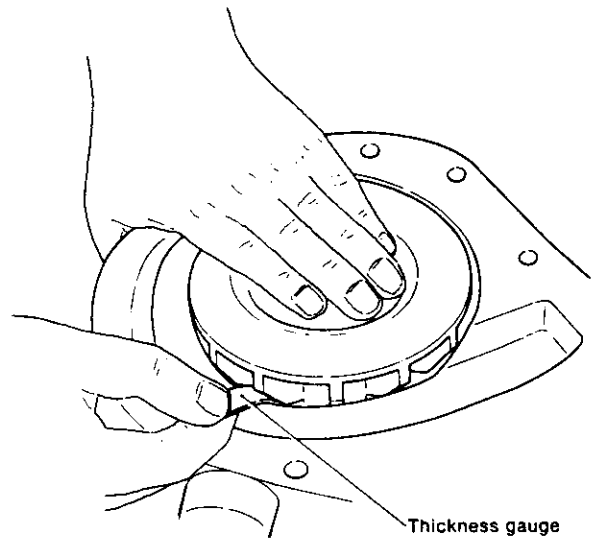
(2) Impeller inspection
Check impeller for damage, corrosion and water. Replace if required.

(3) Check the holes drilled in the cooling water passage or by-pass passage, and clean or unblock where necessary.

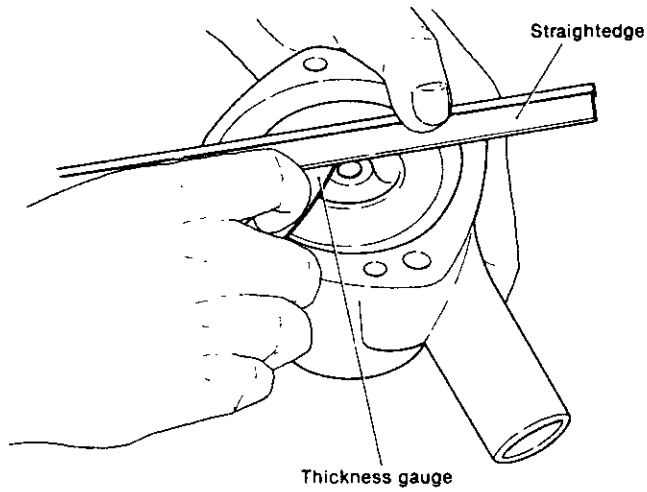




Measuring clearance between impeller and pump body



Measuring clearance between impeller and pump body bracket



(4) Where water leakage is heavy, due to wear or a damaged mechanical seal and impeller seal, replace the pump assembly with a new one.

(5) Pump body and pump bracket inspection
Clean deposits and rust from body and bracket. Replace if heavily worn or corroded.

(6) Impeller clearances.

mm (in)

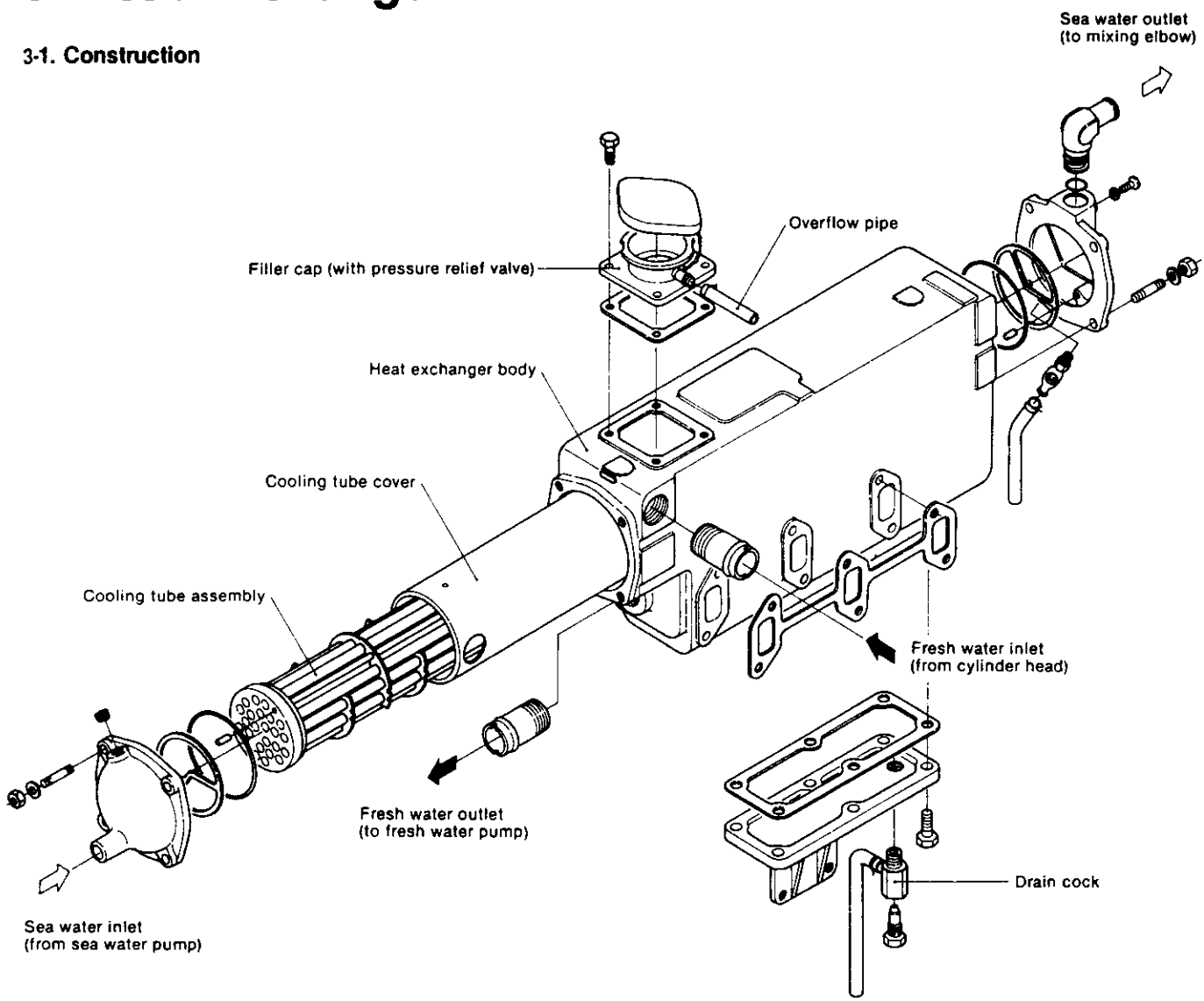
	Maintenance standard
Clearance between impeller and body	0.3 ~ 1.1 (0.0118 ~ 0.0433)
Clearance between impeller and bracket	0.5 (0.0197)

To measure clearance between impeller and body, insert thickness gauge between the two parts at an oblique angle.

To measure clearance between impeller and bracket, place a straightedge on the pump body surface and insert a thickness gauge between the straightedge and impeller.

3. Heat Exchanger

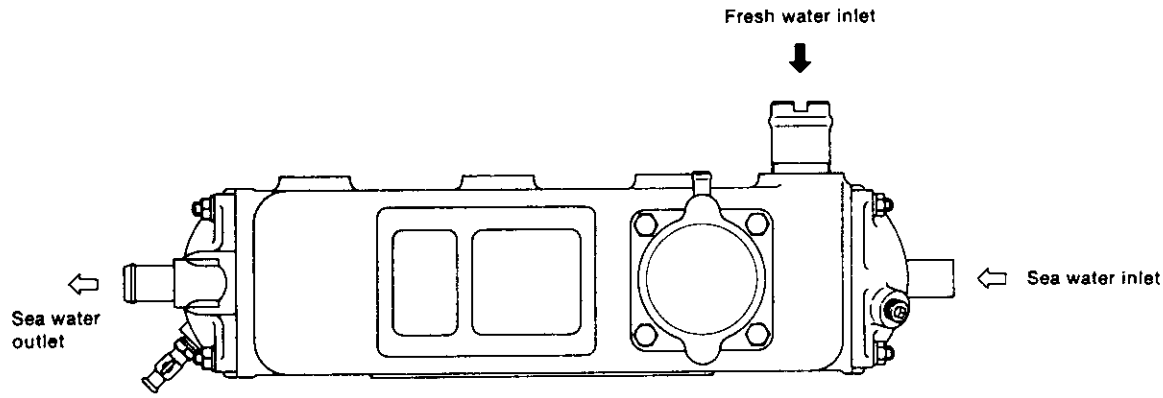
3-1. Construction

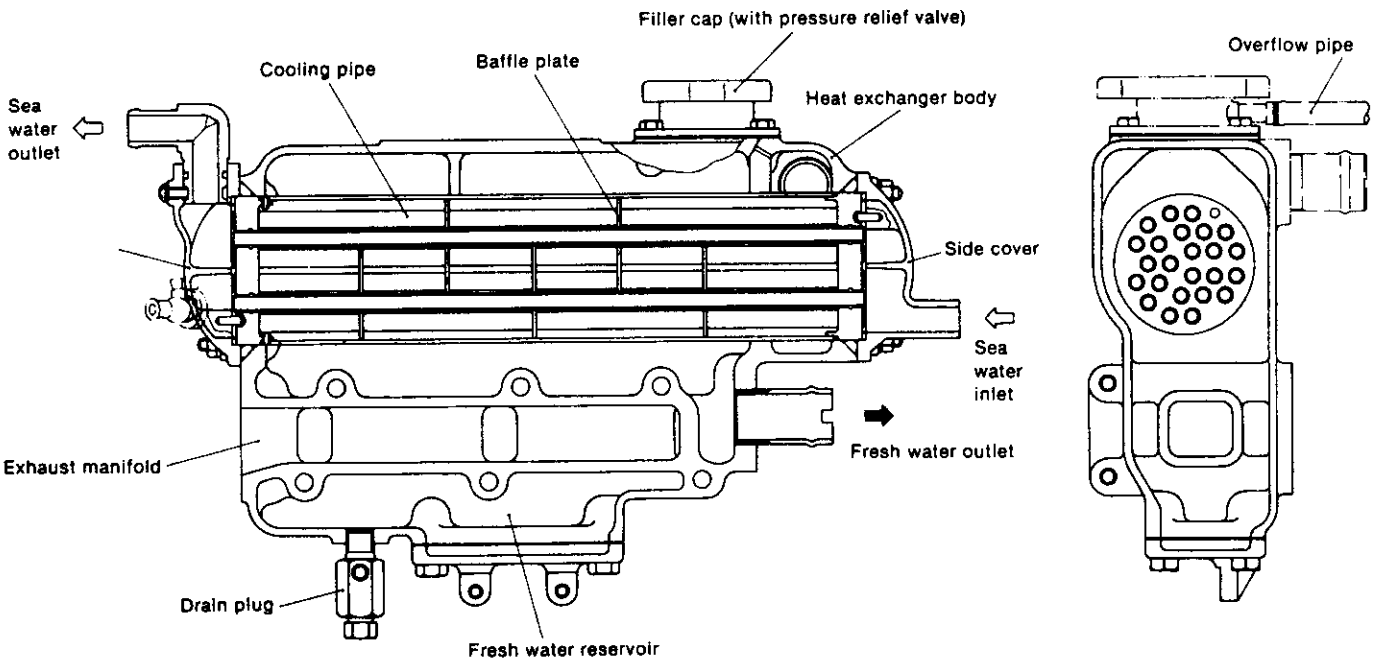


The heat exchanger cools the fresh water, which has reached a high temperature, circulated in the cylinder block, by sea water.
The heat exchanger is a cooling tube which consists of 24 slender tubes and baffle plates, and a cooling tube cover. Sea water passes through the slender tubes, and fresh water passes through the flow path formed outside of the tubes and baffle plates inside the cooling tube cover.
The lower part of the heat exchanger stores the fresh water, acting as a fresh water tank. There is an exhaust gas passage, leading out of the storage position, which is integrated with the water-cooled exhaust manifold.

The filler cap on the top of the heat exchanger is equipped with a pressure relief valve. When pressure exceeds the specified limit, this valve opens to release pressure through the overflow pipe.

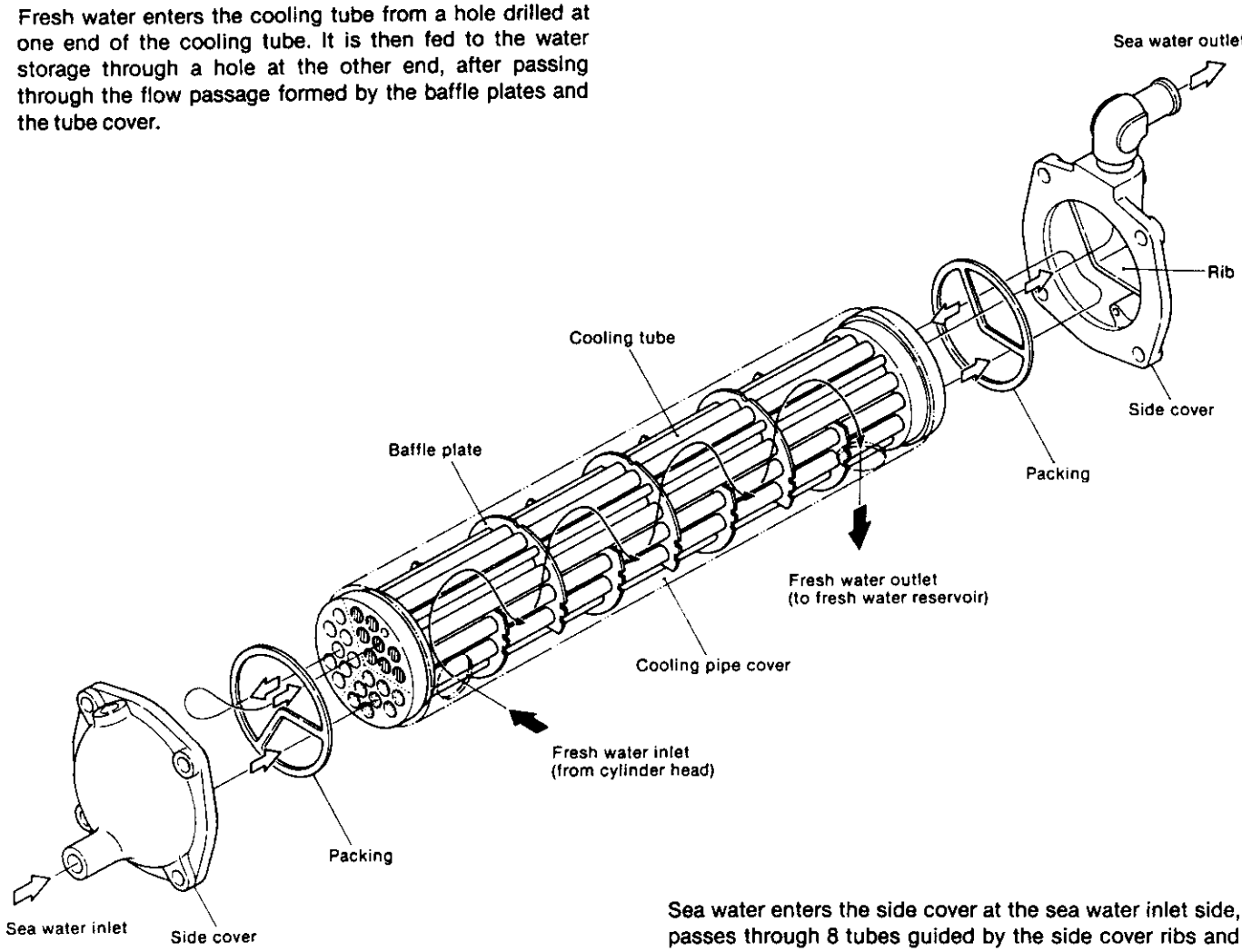
On the other hand, when cooling system pressure becomes negative in relationship to the atmospheric pressure, air enters from the overflow pipe.





3-2. Water flow in water cooling tube

Fresh water enters the cooling tube from a hole drilled at one end of the cooling tube. It is then fed to the water storage through a hole at the other end, after passing through the flow passage formed by the baffle plates and the tube cover.



Sea water enters the side cover at the sea water inlet side, passes through 8 tubes guided by the side cover ribs and then enters the side cover at the sea water outlet side. Here it passes through another 8 tubes guided by side cover ribs, and returns to the side cover at the inlet side.
At the inlet side, it is guided by the remaining 8 tubes as at the outlet side, and then flows out to the mixing elbow from the outlet connection via the side cover at the outlet side.

3-3. Specifications

Model of engine		2GMFY	3GMFY
Output (DIN 6270 B rating)	HP/rpm	15/3600	22.5/3600
Pipe dia. X pieces	mm	ø6/ø8 × 24	ø6/ø8 × 24
Radiation area	m^2	0.119	0.163
Radiation area/HP	m^2/HP	0.0079	0.0072
Fresh water capacity	*l* (cu. in)	2.9 (177.0)	3.4 (207.5)

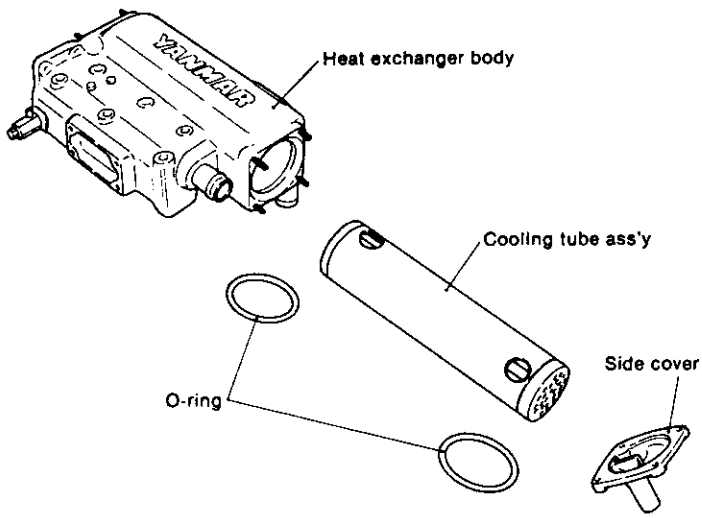
3-4. Disassembly

(1) Remove the side covers and pull out cooling pipe and rubber packings.

NOTE: After cooling pipe is removed, always replace the rubber packings on both side covers.

(2) Remove filler cap and port.

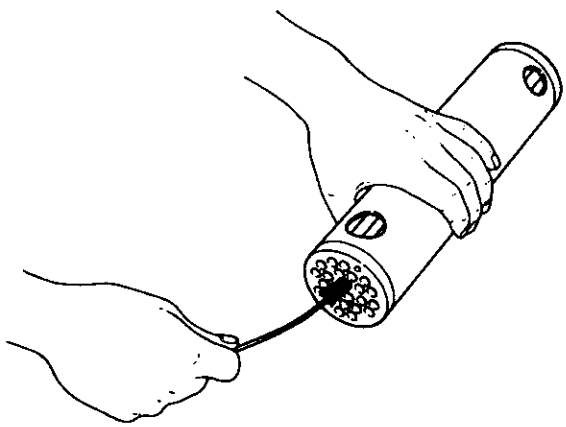
(3) Remove lower cover and packing.



3-5. Inspection and cleaning

Cooling pipe

(1) Inspect for dirt and deposits in the tubes. Clean as required.



(2) Inspect caulked portions of tubes and flanges for damage. Repair or replace as required.

(3) Inspect the cooling pipe and tubes for leaks. Repair as required.

(4) Check for clogged water passages. Clean as required.

Heat exchanger body

(1) Check for dirt and corrosion build-up inside body and on side covers. Replace if corroded, broken or otherwise damaged.

(2) Check joints at sea water inlet and outlet ports and fresh water inlet and outlet ports. Retighten any loose screws and clean pipes as required.

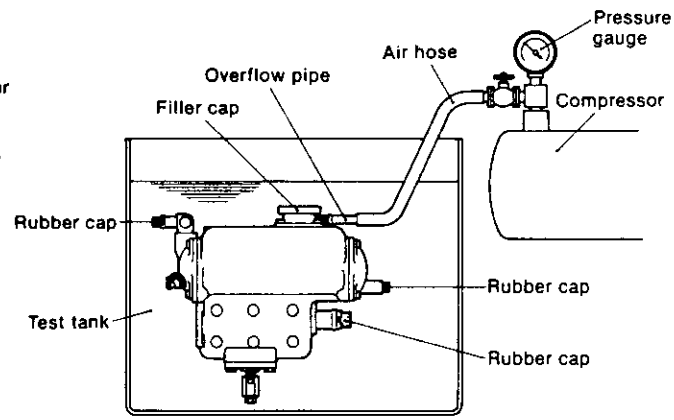
(3) Check drain cock for clogging. If clogged, clean or repair as required. Retighten screws if necessary.

(4) For inspection of filler cap, anticorrosion zinc, and thermostat, see below.

Leakage test

(1) Test with compressed air and test tank. Seal fresh and sea water ports with rubber caps and immerse tank in a test tank filled with water. Inject compressed air through the overflow pipe and check for air bubbles.

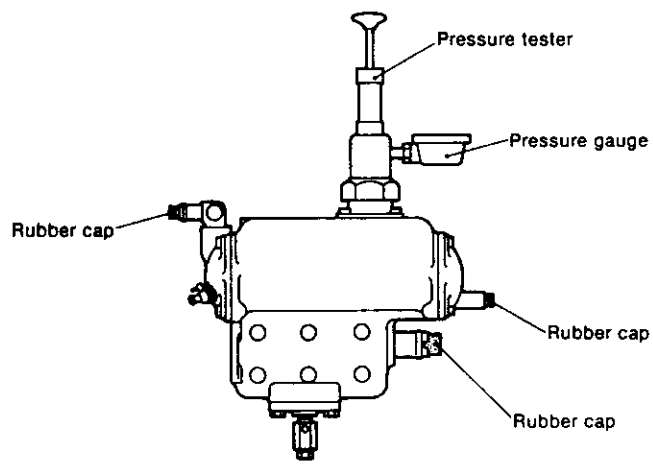
NOTE: Air pressure should be 0.5 ~ 2.0kgf/cm²(7.11 ~ 28.45 lb/in²).



Leakage test using compressed air and test tank

(2) Test using pressure tester

Seal fresh and sea water ports with rubber caps and fill tank completely with water. Replace the filter cap with a pressure tester and pressurize the tank. If a leak is present, the tank cannot be pressurized or it will only be able to retain pressure for a short time.

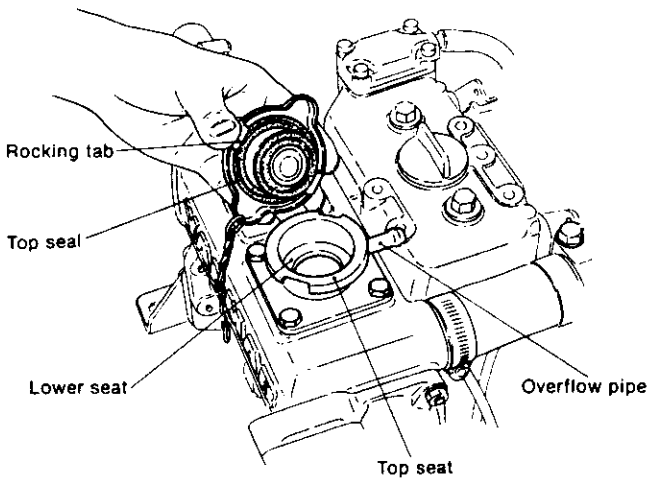


Leakage test using a pressure tester

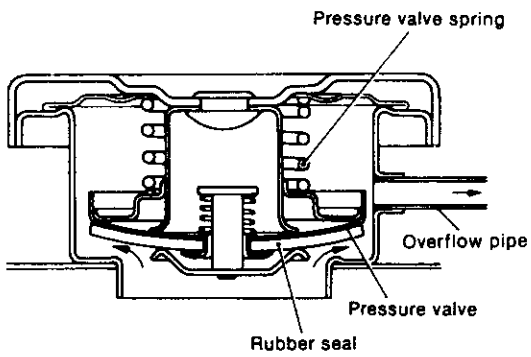
4. Filler Cap and Subtank

4-1. Filler cap construction

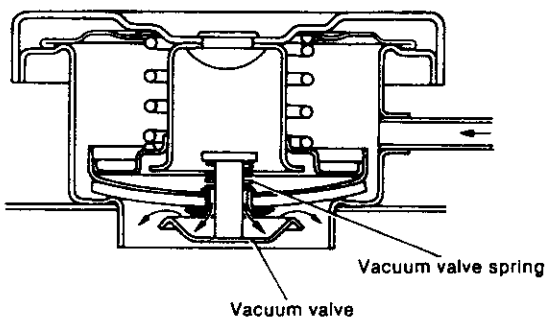
The filler cap is placed on the fresh water inlet port and is equipped with a pressure control valve.
To attach, place the rocking tab (extension on the attachment section) on the flyneck cam. Then, turn and tighten.
The top seal touches the flyneck tap seat while the pressure valve touches the lower seat.



4-2. Filler cap pressure control



Pressure valve operation



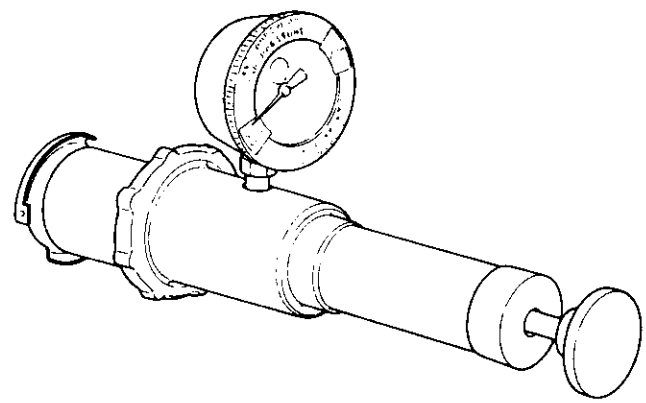
Vacuum valve operation

When cooling system pressure is within the specified range 0.9 kgf-cm² (12.80 lb/in²), the pressure valve and vacuum valve are tightly closed on their valve seats. When pressure rises, the pressure valve opens and vapor is discharged from the overflow pipe. When water becomes cool and pressure in the system is lower than the atmospheric pressure, the vacuum valve opens and air enters the system through the overflow pipe.
To prevent the pressure valve from opening and the resulting water loss, the cooling ystem can be equipped with a subtank, described below.
Action of Pressure control Valve

Pressure Valve	Opens at 0.9 kgf-cm² G (12.80 lb/in²)
Vacuum Valve	Opens at 0.05 kgf-cm² G (0.71 lb/in²) or below

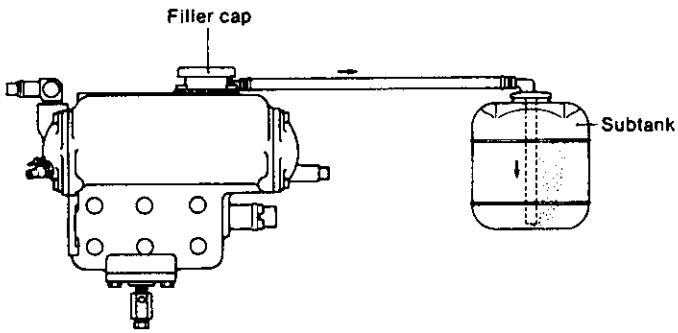
4-3. Filler cap inspection

(1) Remove all deposits and rust, check for damage and wear on the seat contacting surfaces, and check spring for proper functioning. Repair or replace as required.
(2) Tester inspection
Attach adaptor and filler cap to tester.
Increase pressure and if pressure remains constant for six seconds, the cap is normal. If pressure does not increase or does not remain constant for six seconds, check for defects. Repair or replace as required.

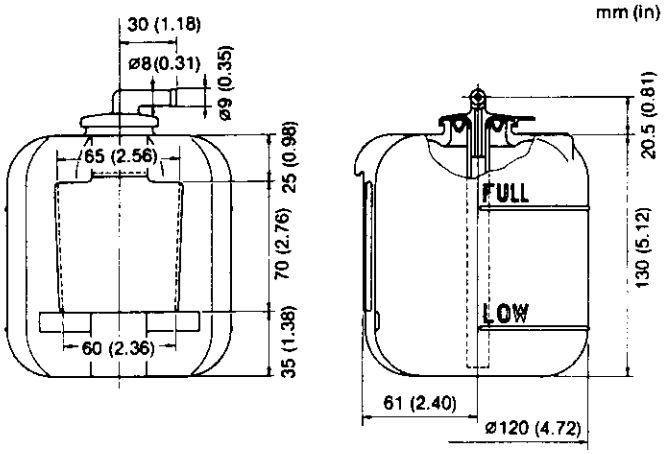


4-4. Subtank function

When cooling system pressure rises above 0.9kgf-cm² (12.80 lb/in²), the pressure valve opens and vapor is released, reducing the amount of water in the cooling system. The subtank collects this vapor where it condenses. Then, when cooling system pressure falls below atmospheric pressure, the water in the subtank is siphoned back to the main tank.
Use of a subtank is highly recommended, since this allows the engine to be run for longer periods between water replenishment and the need to open the filler cap is eliminated, removing one possible cause of accidents.



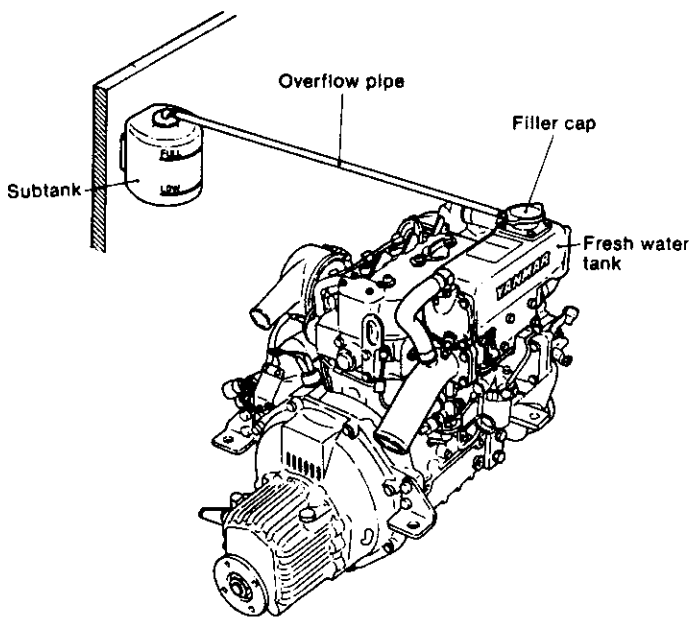
mm (in)



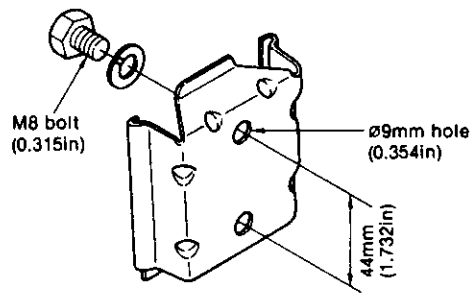
l (cu. in)

Subtank capacity	Over all capacity	1.25 (76.28)
	Full scale position Low scale position	about 0.8 (48.82) about 0.2 (12.20)
Part No.	120445-44530	

4-5. Installation of subtank



Subtank mounting plate (attached to subtank)



(1) Mount the subtank at the same height as the fresh water tank.
(2) Ensure that the length of the overflow pipe is no more than 1m (39.37 in.), and that it does not break.

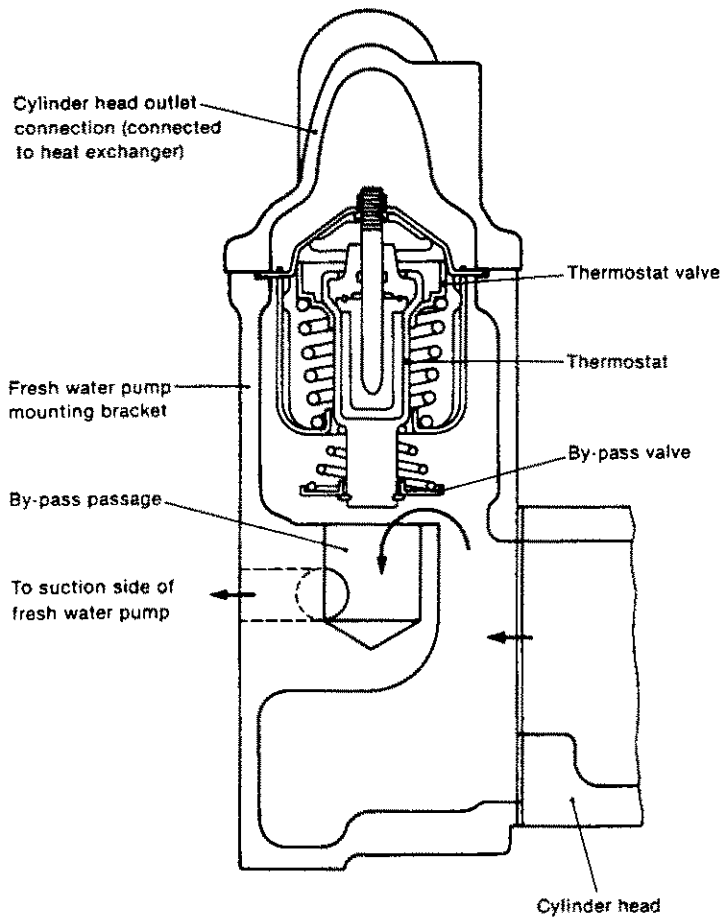
NOTE: If a subtank is not used, be careful not to immerse overflow pipe in the bilge, since this can cause bilge water to be siphoned into the cooling system.

4-6. Maintenance during use

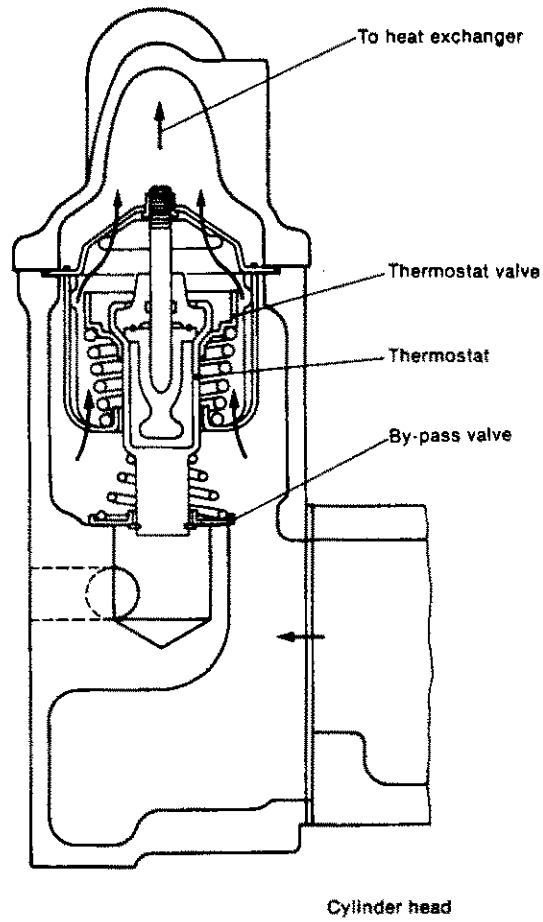
(1) Check that when the cooling water is cold the level is within the specified range.
(2) Check that the overflow pipe is not broken, and also that the holes are not blocked up.

5. Thermostat

5-1. Operation



When valve is closed (by-pass passage is opened)

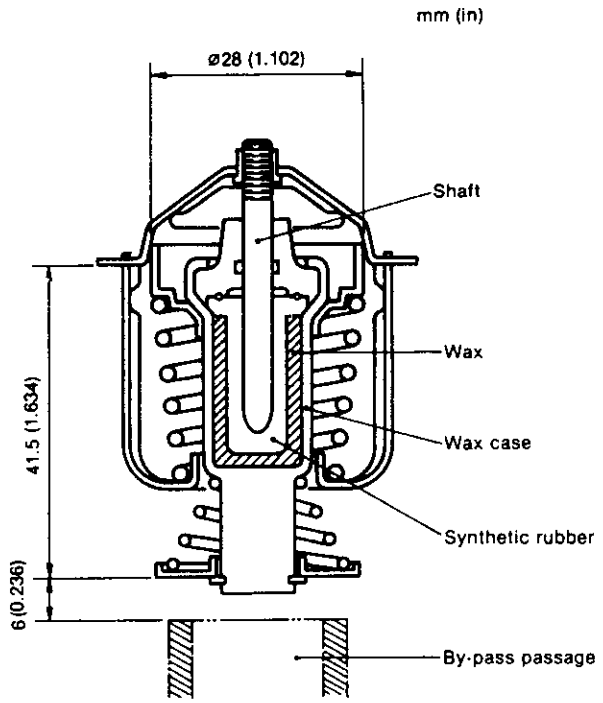


When valve is opened (by-pass passage is closed)

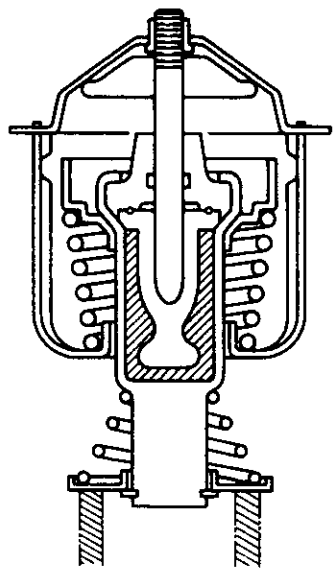
The thermostat opens and closes the by-pass valve and thermostat valve according to the temperature changes in the fresh water in the engine, adjusts the flow of fresh water to the heat exchanger and keeps the fresh water temperature in the engine at the correct degree.
The thermostat in the fresh water-cooled engine is a bottom-by-pass type, as shown in the figure, and is installed inside the fresh water pump bracket which combines with the cylinder head cooling water outlet passage.
The thermostat valve is closed while the fresh water temperature is low, and fresh water is fed to the fresh water pump inlet through the drilled hole in the by-pass passage, and circulated inside the engine.
When the fresh water temperature rises over the valve opening temperature, the thermostat valve opens, and fresh water is fed to the heat exchanger and where fresh water is cooled and then it is fed to the fresh water pump. With the thermostat valve opening, the by-pass passage is throttled. The by-pass passage is completely closed as the temperature rises.

5-2. Construction

A wax-pellet type thermostat is used for this engine. The "wax-pellet" type is the description given to a quantity of wax in the shape of a small pellet. When the temperature of the cooling water rises, the wax melts and its volume expands. The valve is opened or closed by this variation of volume.



When valve is closed

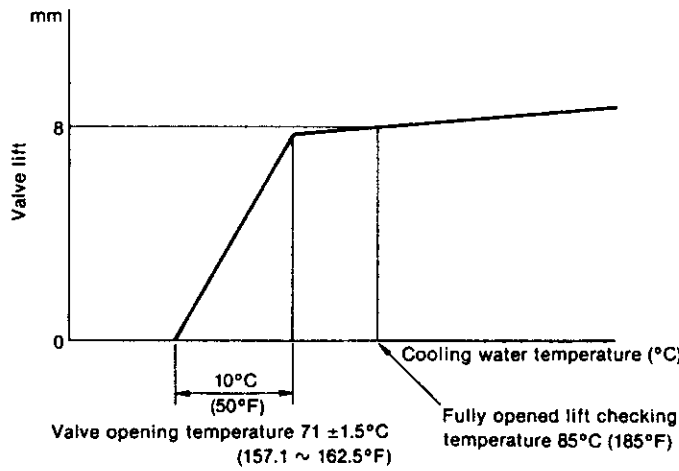


When valve is opened

Thermostat operating temperature °C (°F)

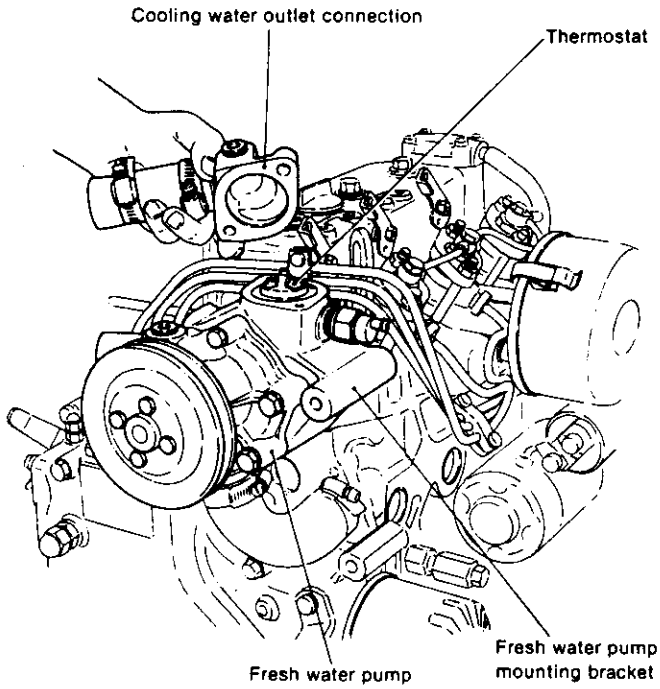
Opening temperature	71° (159.8)
Full open temperature (Temperature corresponding to 8mm or more valve lift)	85° (185)

Characteristic of Thermostat

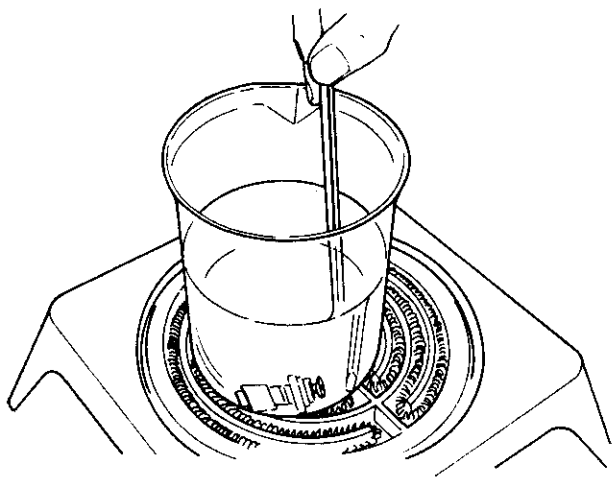


5-3. Inspection

(1) Remove the cooling water outlet connection at the top of the fresh water pump mounting bracket and take out the thermostat.
Remove all deposits and rust, check functioning and inspect parts. Replace if performance has deteriorated or if the spring or other parts are excessively corroded, deformed or otherwise unsuitable.



(2) Testing the thermostat
Place the thermostat in a container filled with water. Heat the container with an electric heater. If the thermostat valve begins to open when the water temperature reaches about 71°C and becomes fully open at 85°C, the thermostat may be considered all right. If its behaviour differs much from the above, or if it is found to be broken, replace it.

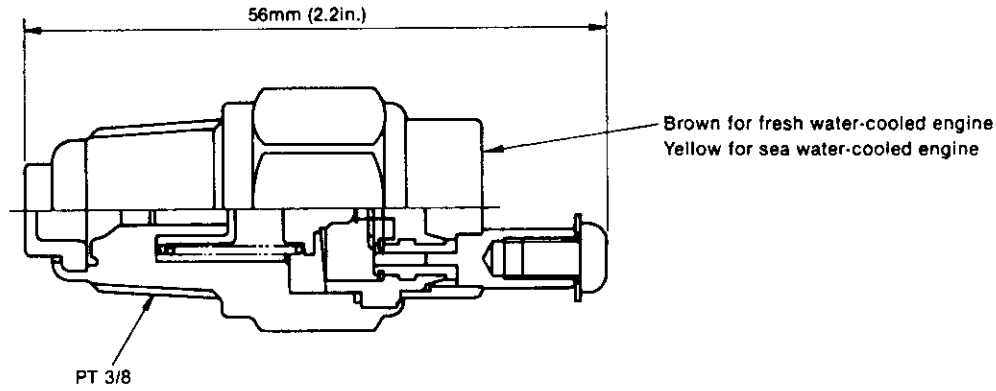


(3) In general, inspect the thermostat after every 500 hours of operation. However, always inspect it when the cooling water temperature has risen abnormally and when white smoke is emitted for a long period of time after the engine starts.
(4) Replace the thermostat when it has been in use for a year, or after every 2000 hours of operation.

Part No. code of thermostat	121750-49800

6. Cooling Water Temperature Switch

The cooling water temperature switch is identical to that for the sea water-cooled engine in shape and dimension, but care must be taken when parts are replaced as the operating temperature is different.
This can be checked by the seal color.



Operating temperature		Current capacity	Response time	Indication color	Parts code
ON	OFF				
106±3°C (217.4 ~ 228.2°F)	96°C (204.8°F) or higher	DC 12V 1A	Within 60 sec.	Brown	127610-91360

7. Precautions

7-1. Ventilator

The surface temperature of fresh water cooled engines is higher than sea water cooled engines. Therefore, if the engine room is not well ventilated, engine room temperature can rise to a point where it will adversely influence engine performance.

7-2. Cooling water

(1) Fresh water
Use clean soft water as cooling water. Hard water will cause calcium build-up, poor heat transmission and a drop in the cooling affect, resulting in overheating.

(2) Fresh water tank capacity

l (cu. in)

Model	Capacity
2GMFY	2.9 (177.0)
3GMFY	3.4 (207.5)

Remove the cap from the fresh water cooler, and check the water level. If the water level is below the top of the cooling pipe, add clean soft water up to the iron plate at the bottom of the filler.
If water is added up to the mouth of the fresh water tank, about 50cc of water will overflow from the filler immediately after the engine is started. This is normal, and is caused by the increase in the volume of the water as its temperature rises. If the water filler cap is removed after the engine has been stopped and allowed to cool, the water level will be 2—3cm from the top of the filler. This is also normal, and is caused by the overflow of the unnecessary water as the temperature of the water rises.

(3) Cooling water (fresh water) level check
Check the level of the cooling water (fresh water) before daily operation. A low cooling water level can cause insufficient pump discharge and the accumulation of scale in the heat exchanger.

(4) Cooling water leakage check during operation
Although checking for water and oil leakage during operation is generally necessary, check for fresh water leakage with special care.
Fresh water leakage is directly related to seizing of the engine.

(5) Fresh water replacement
Replace water every 500 hours. Always use an anti-rust agent.
To drain the water, open the cooling water drain cock and remove the water filler cap. If the filler cap is not removed, a vacuum will be created in the water jacket and all the water will not be drained.

(6) Removing the filler cap
Do not attempt to remove the water filler cap at the top of the fresh water tank while the engine is running, or while the engine is still hot after it has been stopped; steam will escape and may cause serious injury. If removal of the filler cap is unavoidable, place a piece of cloth over the cap and turn the cap slowly, making sure you are in a safe position even if steam escapes.

7-3. Antifreeze

(1) Use permanent type antifreeze in the winter. Freezing of the fresh water will damage the heat exchanger, cylinder head and water jacket.

(2) Antifreeze use
1) Before adding antifreeze, clean cooling system and check for leaks.
2) Select mixing ratio according to the following table.

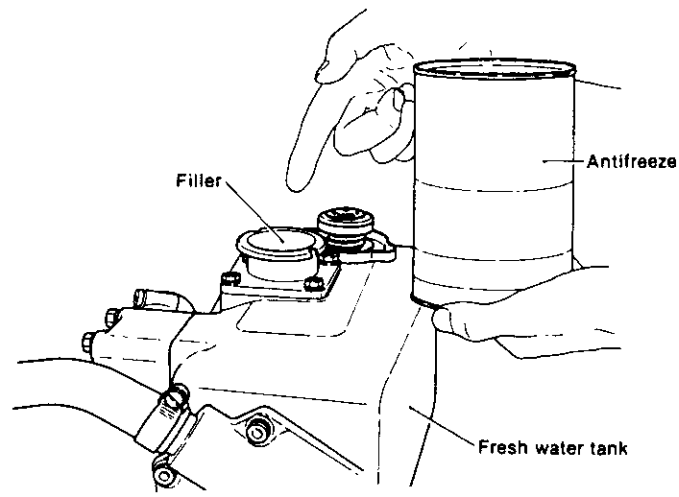
l (cu. in)

Temperature	−5°C	−10°C	−15°C	−20°C	−25°C	−30°C
Mixing ratio	12%	22%	29%	35%	40%	44%
2GMFY	0.35 21.40	0.64 39.10	0.84 51.30	1.02 62.20	1.16 70.80	1.28 78.10
3GMFY	0.41 25.00	0.75 45.80	0.99 60.40	1.19 72.60	1.36 83.00	1.50 91.50

NOTE: The temperature selected in the above table should be 5°C lower than the lowest expected temperature in the area.

NOTE: Check mixing ratio carefully, especially when using premixed coolant.

3) Tighten drain cock and fill cooling system. Then, run engine for approx. 5 to 30 minutes to make sure the solution is well mixed.



NOTE: Some antifreeze solutions will corrode aluminum. Check carefully before use.

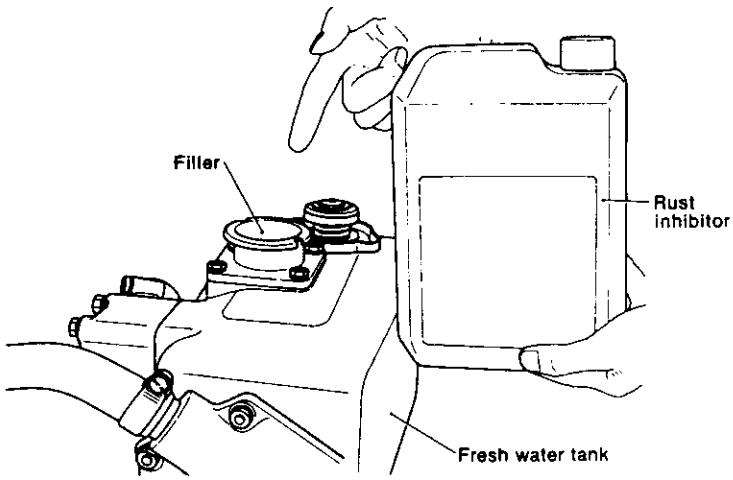
NOTE: When antifreeze protection is no longer necessary, drain water, flush cooling system and refill with fresh water.

7-4. Rust inhibitor

When the fresh water is changed, a rust inhibitor must be added to the new water to prevent rusting.

Rust inhibitor : Fresh water = 1 : 10

Flush cooling system with fresh water, fill with proper rust inhibitor and then top-off cooling system with fresh water.



7-5. Idling the engine when stopping

Always idle the engine for ten minutes immediately after starting and prior to stopping. Be sure to idle the engine adequately, especially before stopping. Stop the engine only after its temperature has dropped sufficiently. If the engine is stopped while hot, the hot fresh water will cause the temperature of the water in the heat exchanger pipe to rise, causing a build-up of calcium deposits in the pipe and a drop in the cooling affect.

7-6. Cleaning the heat exchanger tube

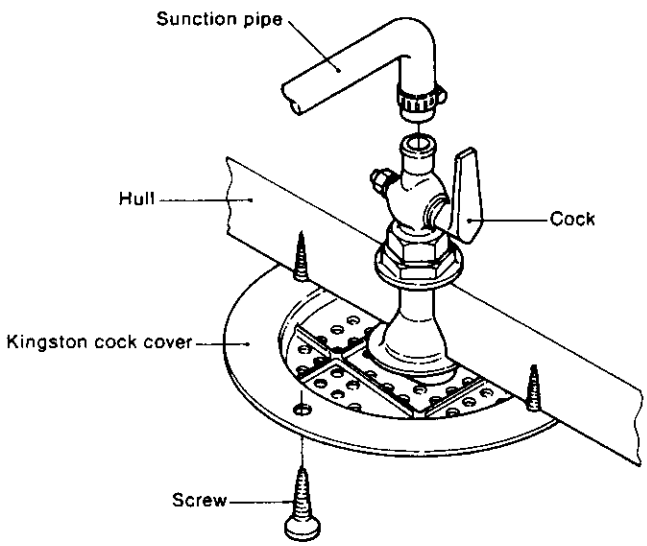
If the heat exchanger tube through which the fresh water flows becomes extremely dirty, the cooling effect will deteriorate.

If the C.W. warning lamp lights periodically when the engine is run at the rated output, clean the tube in the fresh water tank with a cleaning agent and then flush the accumulated scale produced by cooling the fresh water from the tube.

8. Kingston Cock (Optional)

8-1 Construction

The Kingston cock, installed on the bottom of the hull, controls the intake of cooling water into the boat. The Kingston cock serves to filter the water so that mud, sand, and other foreign matter in the water does not enter the water pump.
Numerous holes are drilled in the water side of the Kingston cock, and a scoop strainer is installed to prevent the sucking in of vinyl, etc.



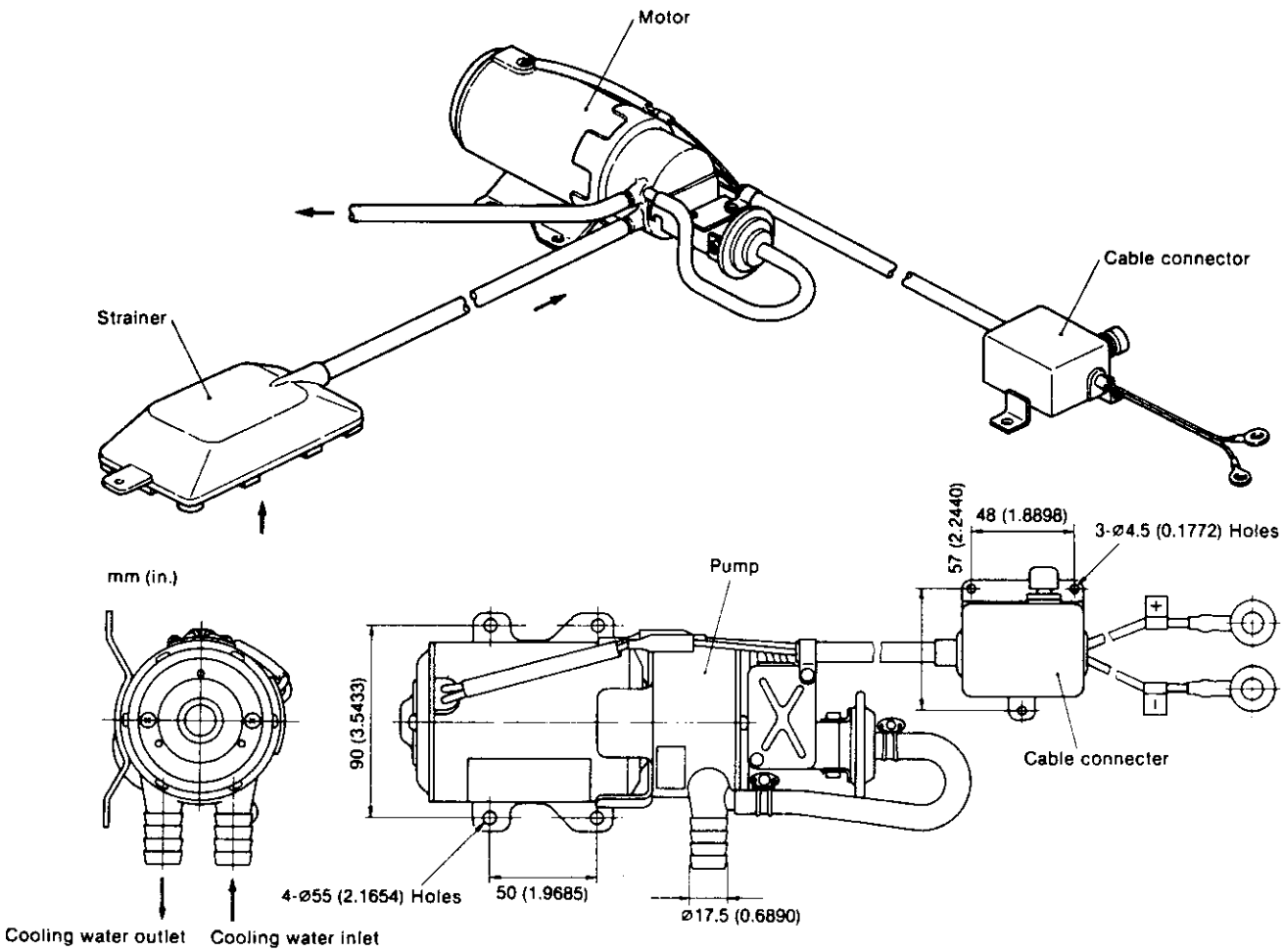
8-2 Handling precautions

Caution the user to always close the Kingston cock after each day of use and to confirm that it is open before beginning operation.
If the Kingston cock is left open, water will flow in reverse and the vessel will sink if trouble occurs with the water pump.
Moreover, if the engine is operated with the Kingston cock closed, cooling water will not be able to get in, resulting in engine and pump trouble.

8-3 Inspection

When the cooling water volume has dropped and the pump is normal, remove the vessel from the water and check for clogging of the Kingston cock.
Moreover, when water leaks from the cock, disassemble the cock and inspect it for wear, and repair or replace it.

9. Bilge Pump and Bilge Strainer (Optional)



9-1 Bilge pump

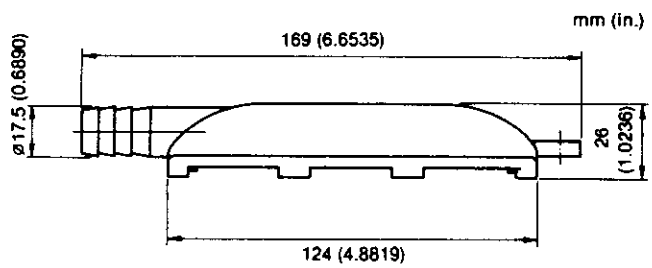
(1) Specifications

Code No.	120345-46010 (with strainer)
Model No.	BP190-10
Rating	60 min.
Voltage	12V
Output	90W
Weight	3.0kg (6.6 lb)

(2) Performance of pump (in pure water)

Self-suction performance	Voltage	11.5V
	Max. self-suction lift	1.2m (3.94 ft)
	Self-suction time	4 sec.
Pumping lift performance	Voltage	11.5V
	Current	8A
	Total lift	1m (3.28 ft)
	Lifting volume of water	17 *l*/min

9-2 Bilge strainer



CHAPTER 7

REDUCTION AND REVERSING GEAR

For engine model 2GMFY and 3GMFY

1. Model Y-5M Sectional View 7-1
2. Model YX-6-1 Clutch Sectional View 7-11
3. Principal Specifications 7-13
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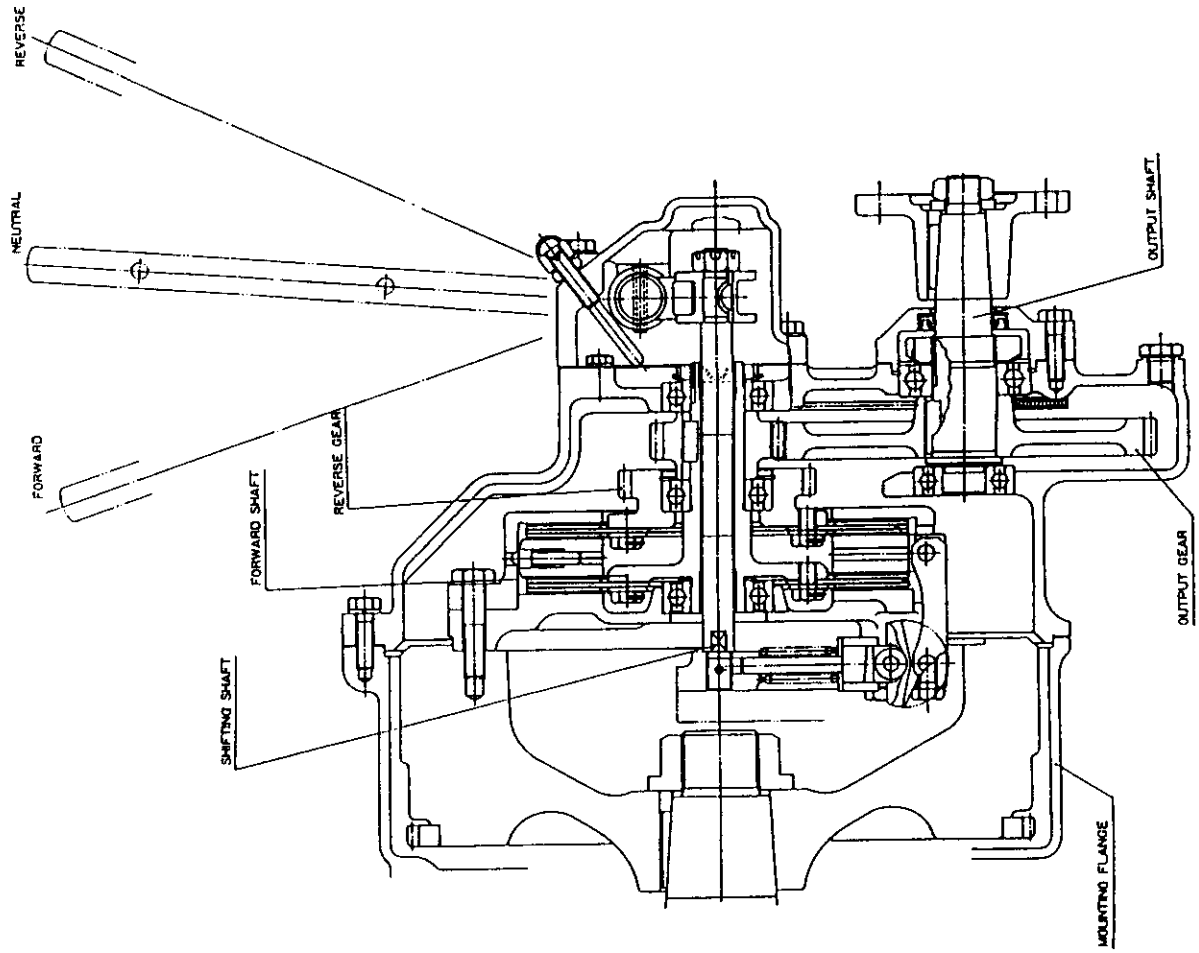
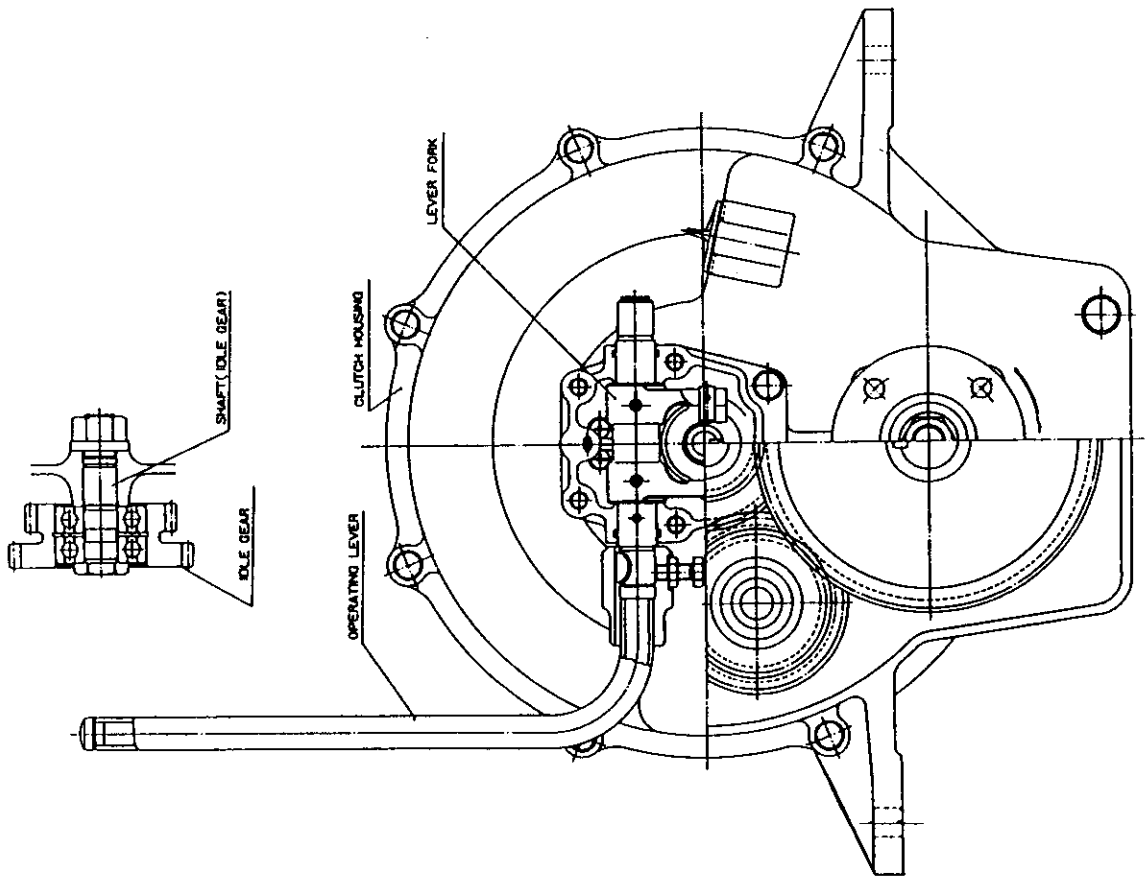
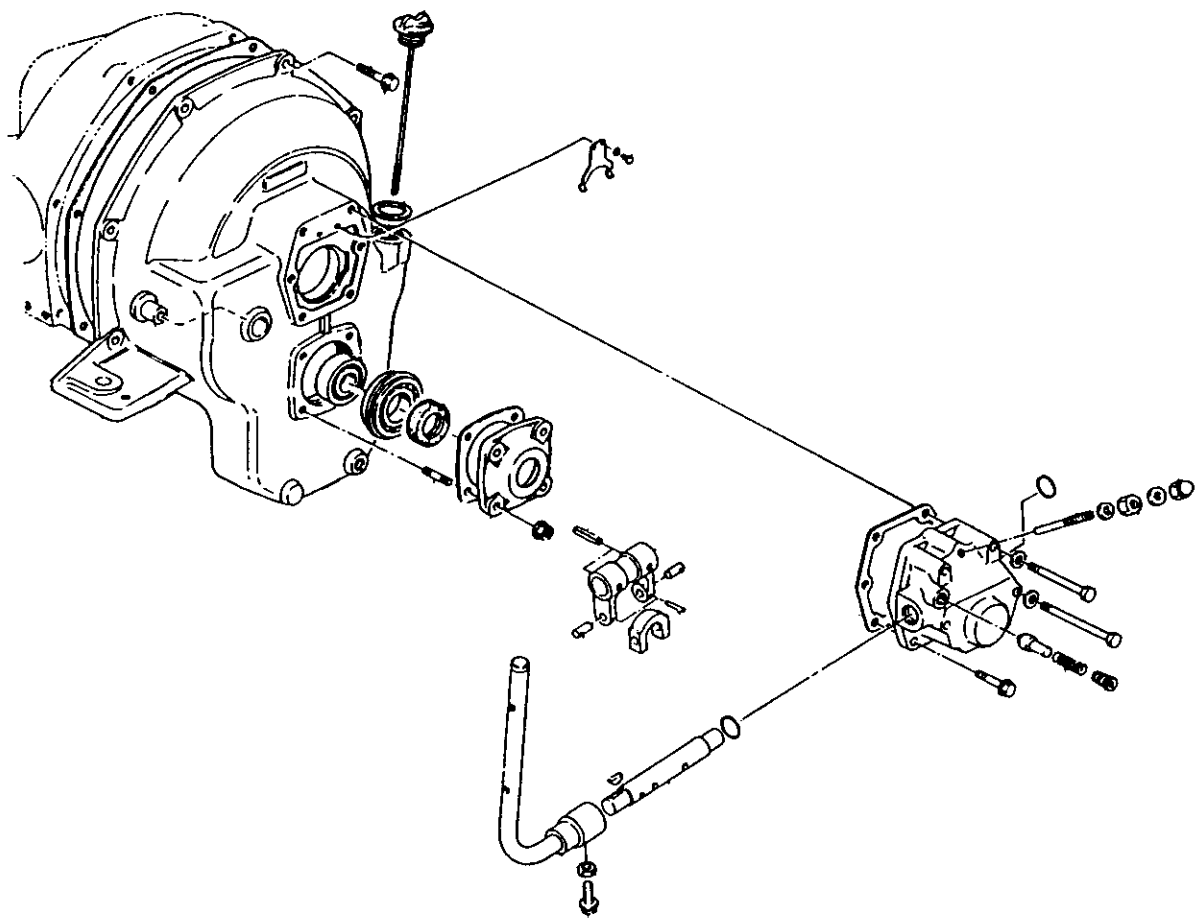
5. Structure 7-15
6. Handling 7-16
7. Service Standard 7-19
8. Troupleshooting 7-20
9. Disassembly and Reassembly 7-21

1. Model Y-5M Sectional View

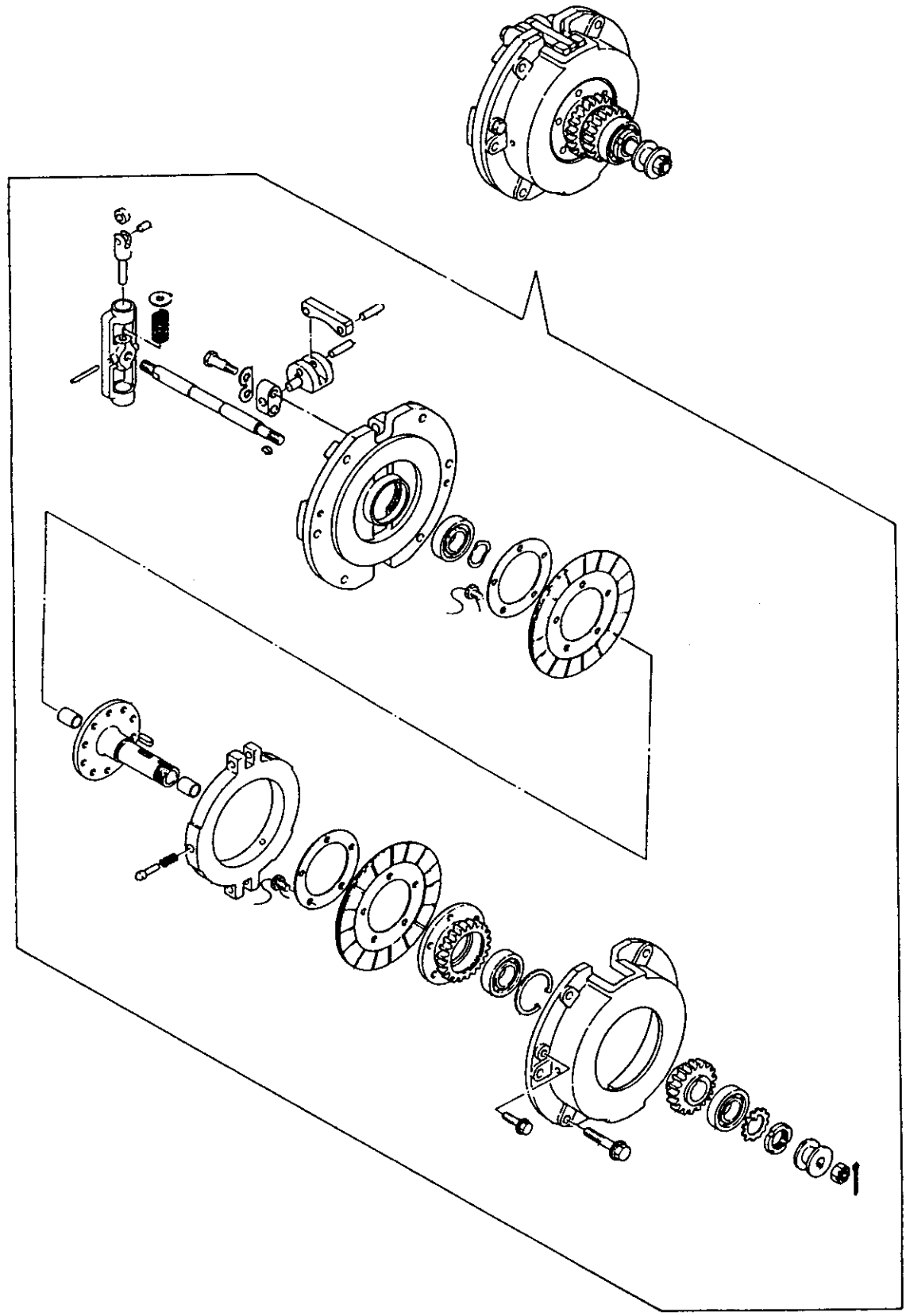




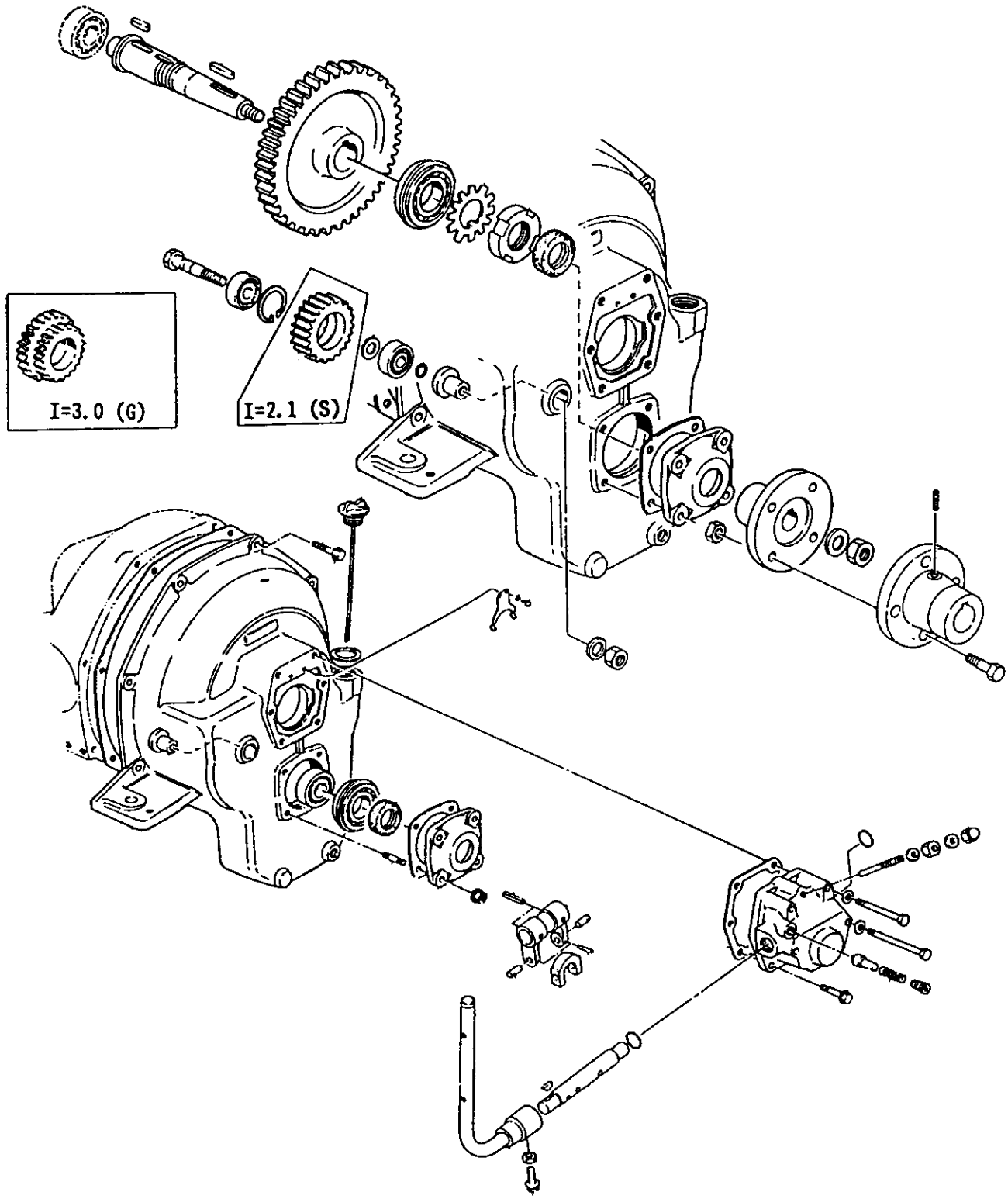
1-1. Clutch Housing (Y-5M)



1-2. Friction Disk Housing (Y-5M)



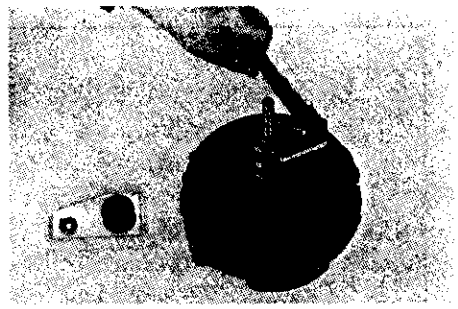
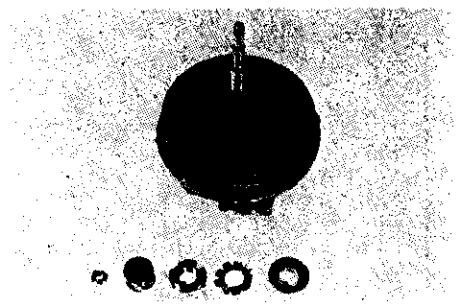
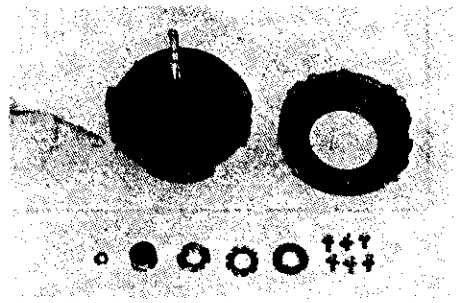
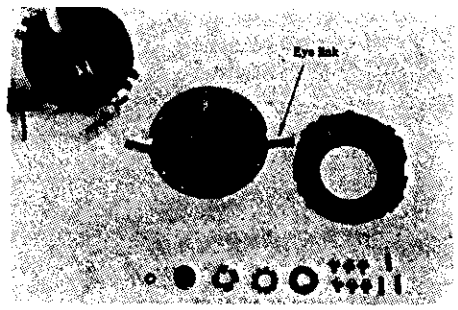
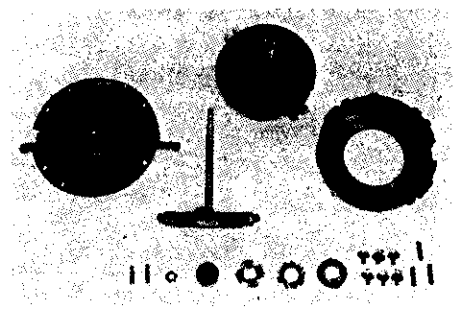
1-3. Output Shaft (Y-5M)

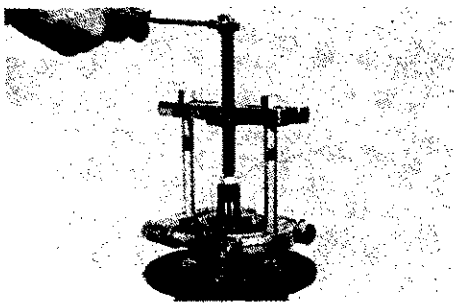
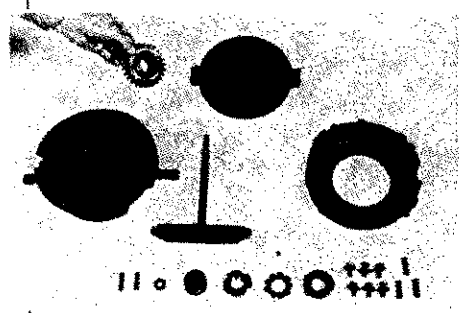
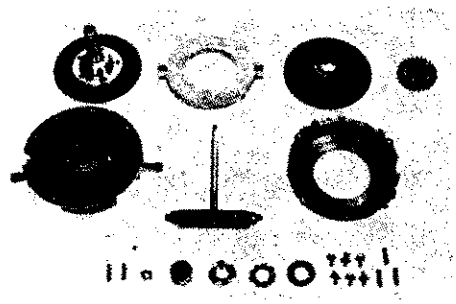
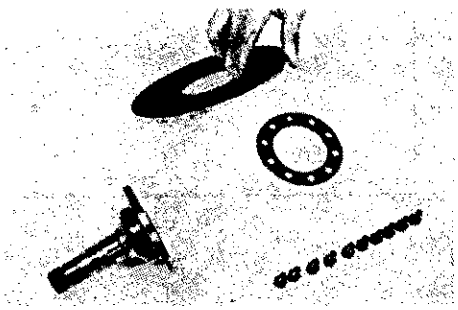


1-4. **Disassembly and Reassembly of Major Components.**

Disassembly of reduction/reverse gear.

Item	Procedure	Illustration
1. Clutch assembly.	• Note the numbers stamped on mating surfaces. • Remove cotter pin, nut, and shifter. • Note semi-circular key.	

Item	Procedure	Illustration
	• Straighten lock washer and remove locknut.	
	• Remove ball bearing.	
	• Remove housing (B). • Including locating pin and springs	
	• Remove the two clevis pins and swing clevis arms outward. • Remove ahead and astern friction plate assemblies.	
	• Remove shifting shaft assenbly.	

Item	Procedure	Illustration
	• Remove ahead gear.	 
	• Remove ahead shaft, friction plate assembly, and retainer friction disc. • Check friction plates, and retainer friction disc for damage.	
	• Remove ahead and astern friction plate assemblies.	

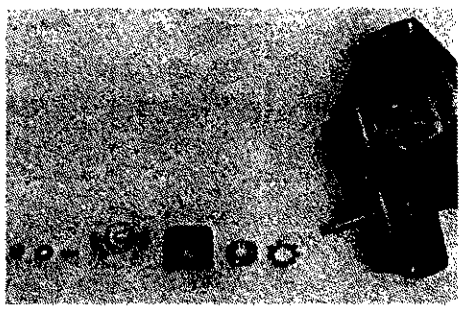
Reassembly of clutch ass'y.

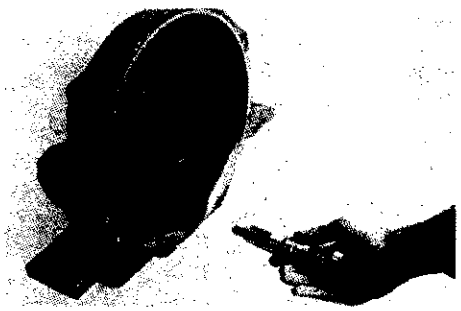
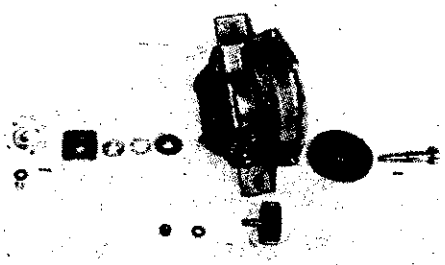
Item	Procedure	Illustration
1. Cutch assembly.	• Install ahead friction plates and astern friction plates on ahead shaft and astern gear. • Be sure that safety-wire pulls in direction in which bolts are tightened. • Place friction retainer plate between ahead shaft friction plate assembly and astern gear friction plate assembly.	

Item	Procedure	Illustration

	• Install ahead gear.
	• Place shifting shaft assembly in housing A.
	• Install ahead and astern friction plate assemblies.
	• Refit link arms and insert clevis pins.
	• Insert locating pins and springs in friction retainer plate.
	• Install housing B.
	• Install ball bearing.
	• Install lock washer and lock nut.
	  • Use new lock washer.
	  • After bending tabs on lock washer, check to be sure that rotation of ball bearing is not interfered with.
	• Install shifter and nut; insert cotter pin.
	  • Use new cotter pin.
	• After assembly is completed, check for ease of rotation of ahead and astern gears.	

Disassembly of clutch speed reduction unit:

Item	Procedure	Illustration
1. Thrust shaft coupling	• Remove thrust shaft coupling. • Remove key. • Remove rear cover of thrust shaft. • Take care not to damage oil seal. • Remove mounting nut and lockwasher.	

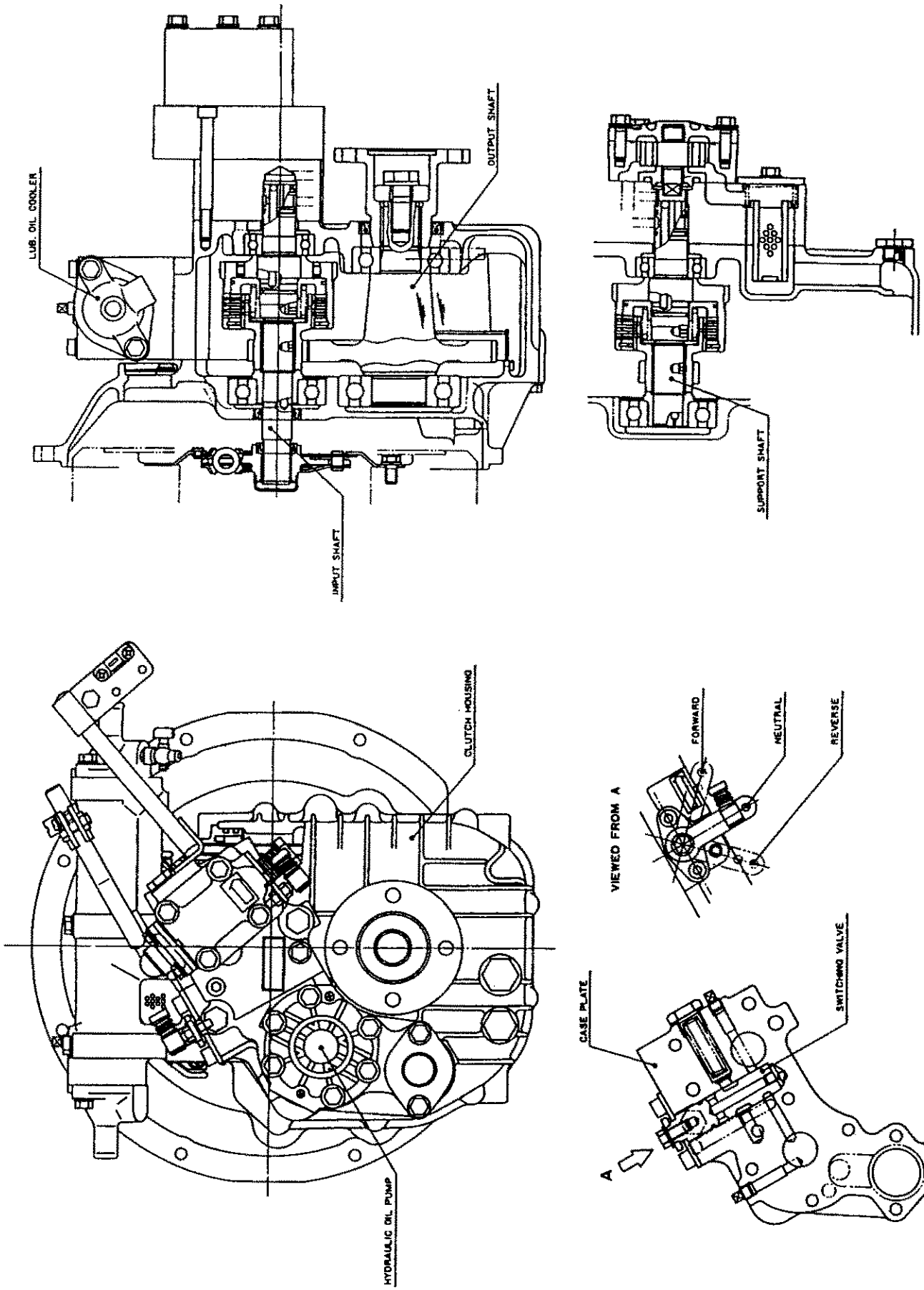
Item	Procedure	Illustration
2. Idler gear.	• Remove mounting nut and washer. • Withdraw idler gear together with shaft.	
3. Thrust shaft.	• Remove thrust shaft. • Remove final reduction gear. • Do not misplace the key.	 

Reassembly of clutch speed reduction unit:

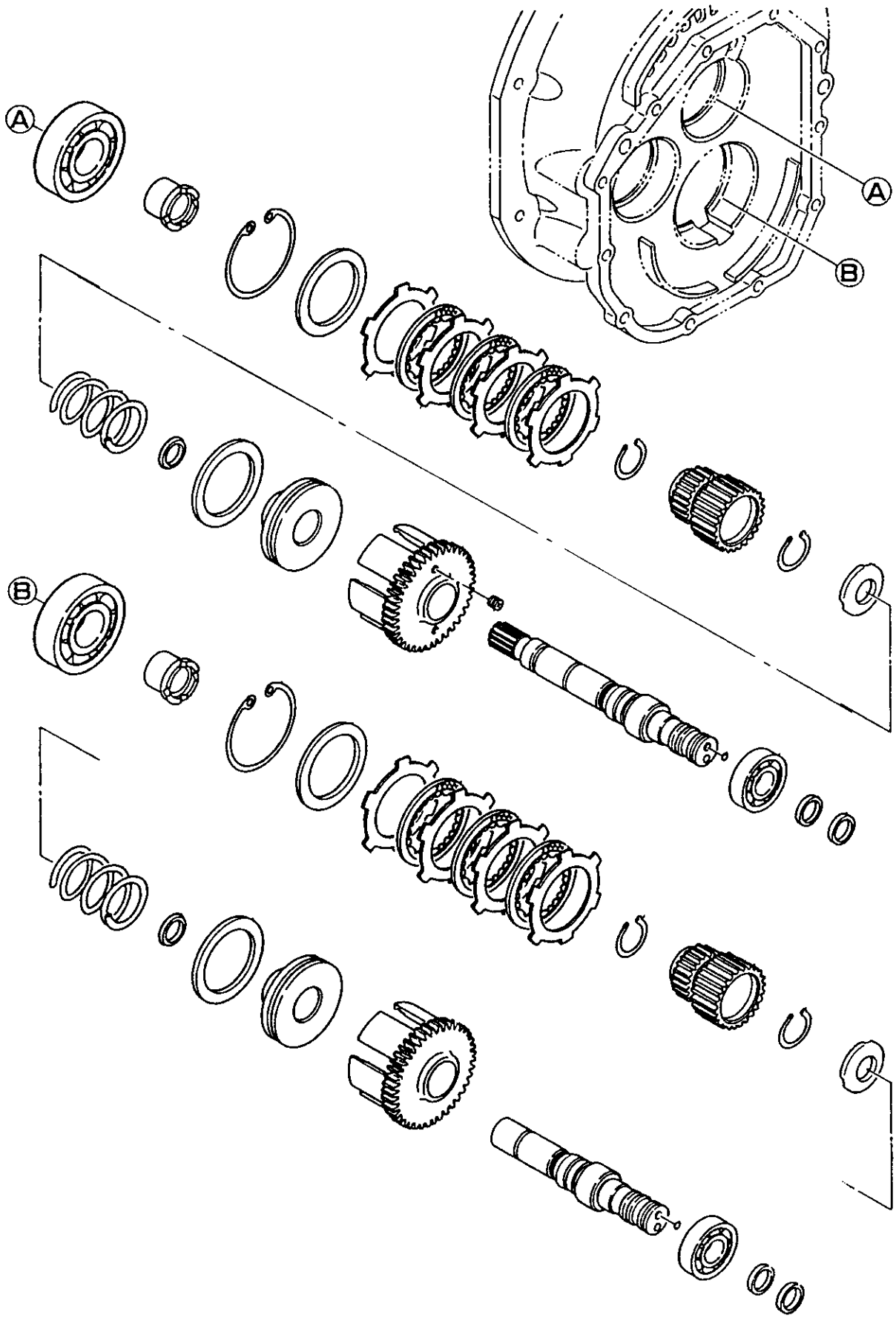
Item	Procedure	Illustration
1. Thrust shaft.	• Install final reduction gear in clutch case. • Set key in thrust shaft. • Install thrust shaft. • Insert bearing.	
2. Idler gear.	• Use new O-ring on idler gear shaft. • Install idler gear/shaft assembly; tighten mounting nuts.	

Item	Procedure	Illustration
3. Thurst shaft coupling.	• Use new lockwasher. • Tighten mounting nut. • Distinguish between inside and outside faces. • Install rear cover of thrust shaft. • Install thrust shaft key. • Install coupling. • After assembly is completed, check for case of rotation of shafts.	

2. Model YX-6-1 Clutch Sectional View



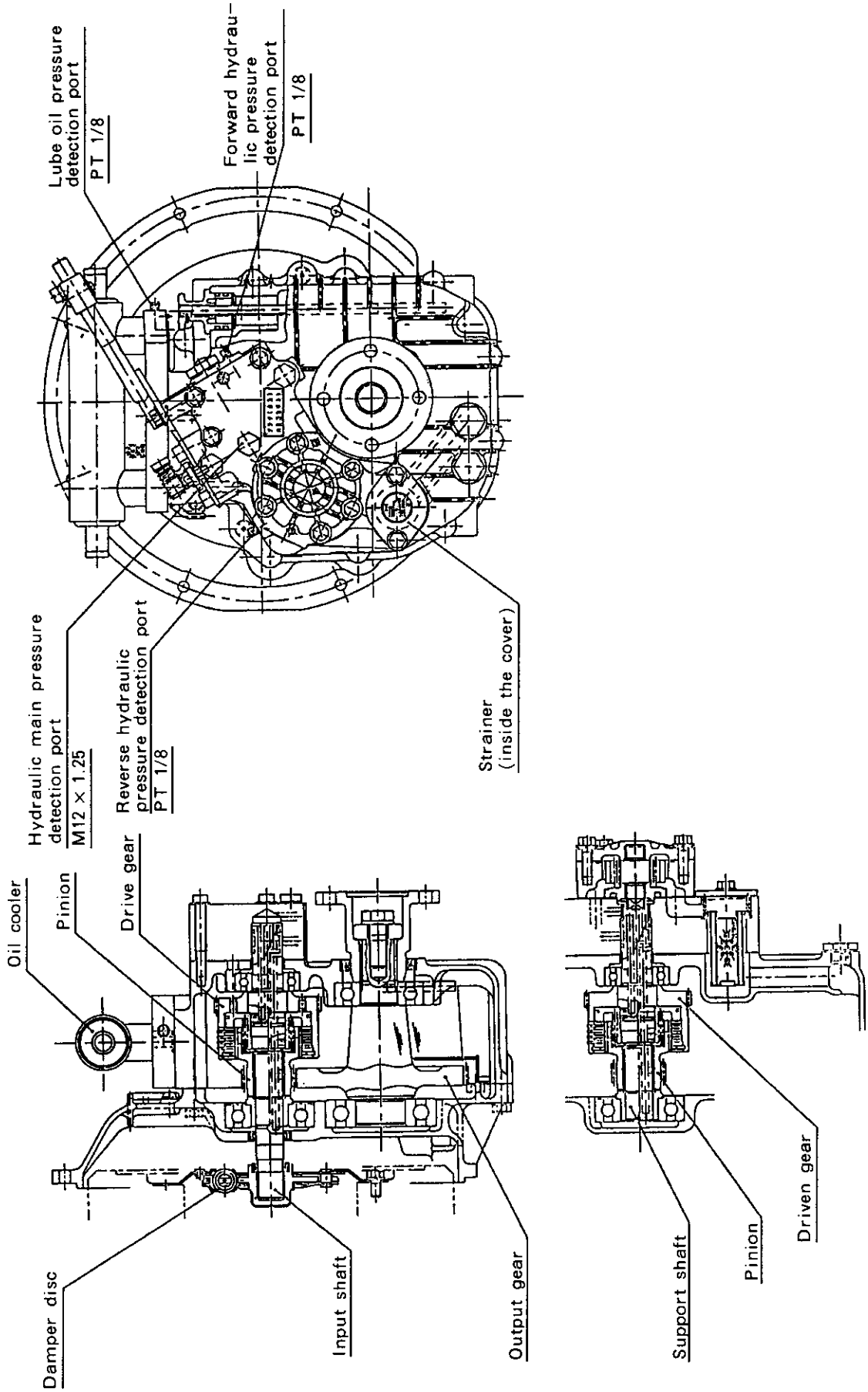
2-1. Input & Support Shaft



3.Principal Specifications

YX-6 Reduction Reverse Gear

Clutch capacity		21 PS/3400 rpm			
Input shaft allowable rev. speed		500~3800 rpm			
Rev. direction (viewed from stern)	Input shaft	Counterclockwise			
	Output shaft	Clockwise (on forwarding)			
Reduction ratio(for both forward & reverse)		3.48	2.96	2.55	2.03
Hydraulic oil pressure (at rated engine speed)		9.5~10.5 kg/cm^2			
Lube oil pressure (at rated engine speed)		1.5~3.0 kg/cm^2			
Lube oil		SAE #30 or equivalent			
Max. lube oil capacity(effective)		1.5 ℓ (0.3 ℓ)			
Eng.revs. for clutch switching	Neutral→ Forward/Reverse	Below 1000 rpm			
	Forward←→Reverse	Below 1000 rpm			
Lever control force		Below 30 kg-cm			
Oil cooler	cooling water temp	Below 45℃ (inlet side)			
	cooling water q'ty	750~1500 ℓ/h			
Dry weight		28 kg (excluding 0.9 kg engine side joint & 1.3 kg coupling)			

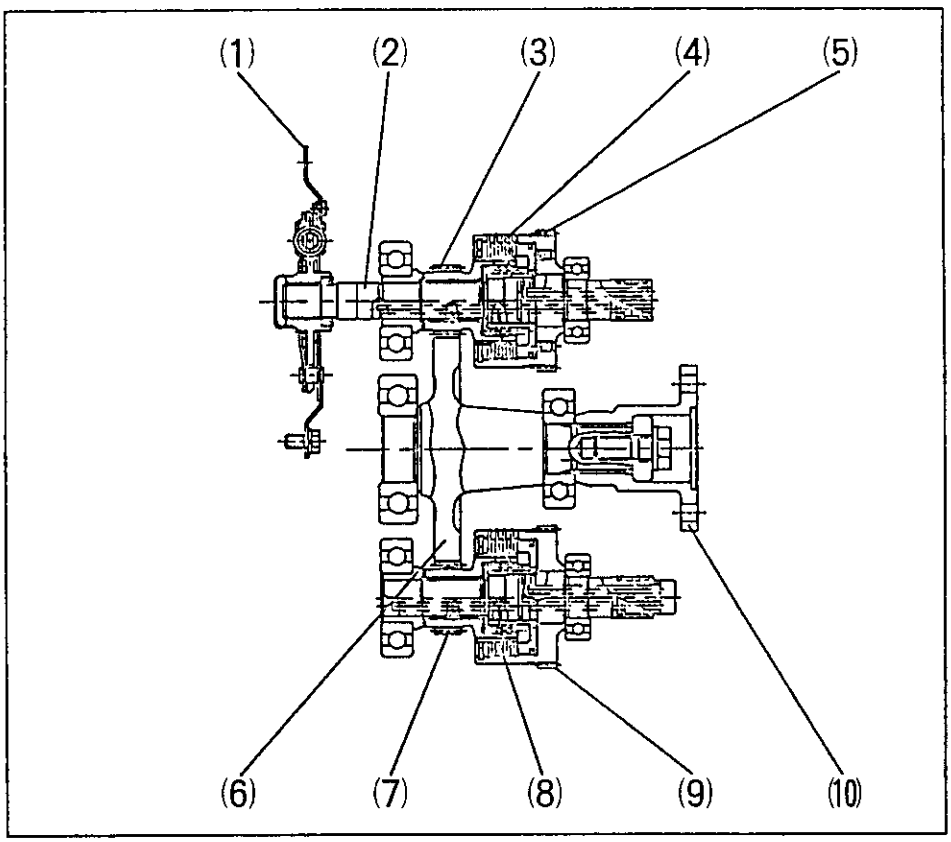

Lube oil pressure detection port PT 1/8
Forward hydraulic pressure detection port PT 1/8
Hydraulic main pressure detection port M12 × 1.25
Reverse hydraulic pressure detection port PT 1/8
Strainer (inside the cover)
Oil cooler
Pinion
Drive gear
Damper disc
Input shaft
Output gear
Support shaft
Pinion
Driven gear

4. Outline

The YX-6 houses the reduction gears and hydraulic multi-disc clutch for forwarding and reversing and reduces the diesel engine revolutions for transmission to the propeller shaft. Changeover between reverse and neutral is easy by clutch operation. There is no need to install a bearing to receive the propeller's thrusting force because a bearing is already housed inside.

5. Structure

5-1 Power Transmission Route



Revolutions in Neutral

Input shaft coupling(1) → Input shaft(2) → Drive Gear(5) → Driven Gear(9)

Revolutions in Forward

Input shaft coupling(1) → Input shaft(2) → Forwarding clutch(4) → Forwarding pinion(3) → Output gear(6) → Output shaft coupling(10)

Revolutions in Reverse

Input shaft coupling(1) → Input shaft(2) → Drive gear(5) → Driven gear(9) → Reversing clutch(8) → Reversing pinion(7) → Output gear(6) → Output shaft coupling(10)

5-2 Hydraulic System

The lube oil in the oil pan is sucked up by the pump through the strainer and sent to the clutch hydraulic pressure control valve where the pressure is regulated. The oil is then sent to each clutch by the forward/reverse switch valve. The pressure of the remaining oil not supplied to the clutch is regulated by the lube oil pressure control valve for use in lubricating the clutch bush and some of the ball bearings.
Splash lubrication is provided for the gears and ball bearings.

5-3 Clutch

In the hydraulic wet type multi-disc clutch, the spline of the forward and reverse pinion meshes with the friction plate, which has the spline on its inner circumference.
The outside circumference of the steel plate meshes with the drive gear and driven gear. The steel plates and friction plates are assembled by turns. When the pressurized oil pushes against the hydraulic cylinder (clutch piston), the steel plates and friction plates are pressed together to transmit power. When the pressurized oil is drained, the hydraulic cylinder is pushed back to disengage the clutch automatically.

5-4 Switch Valve and Clutch Oil Pressure Control Valve

The switch valve distributes the pressurized oil from the gear pump to the forward or reverse clutch by switching the oil passages in the valve.
The clutch oil pressure control valve controls the oil pressure of the clutch.
When the switch valve is operated, the hydraulic oil in the clutch flows through the groove of the switch valve and oil gallery (groove or drilled hole) to press on the hydraulic cylinder. When the switch lever is returned to neutral, the pressurized oil pressing on the hydraulic cylinder is drained instantly and the clutch is disengaged.
The remaining oil not fed to the clutch oil pressure control valve flows to the lube oil control valve, where the pressure is regulated, to lubricate each part.

6. Handling

6-1 Type of Oil

(1) The oil must be stable against temperature changes. It should also possess high acid- and water-resisting characteristics to give no adverse effect on the oil seals, O-rings(nitrile based rubber), gear faces, friction plates (paper based), etc.
Use API CC grade or higher grade oil with an SAE viscosity index or 30 or the equivalent viscosity.
Recommended Oil: Yanmar Marine Super Oil SAE30

(2) Oil Replacement Interval

1 st time	50 hours. after initial operation *
2 nd time	250 hours. after initial operation
3 rd time & thereafter	Every 1000 hours. of operation

*1) Black oil may be noted at the initial oil exchange, but this is not a problem.
2) If cooling water has entered the marine gear, disassemble it completely and clean the inside. Replace all of the oil and check that there is no emulsification in the oil.

6-2 Preparations before Starting & Starting

(1) Preparations
  (a) Check the entire marine gear and confirm that there are no loose bolts and nuts.
  (b) Check the oil level. (Check the oil level before starting the engine or 15 minutes after stopping. Fully insert the oil dipstick to check. Resupply oil up to the upper limit of the dipstick.)
  (c) Shift the handle to neutral.

(2) Starting
  (a) Operate the engine at low speed and check for oil leakage, abnormal sounds and temp. rise.
  (b) Raise the engine speed gradually and check the clutch oil pressure and lube oil pressure. The clutch oil pressure should normally be 8-11 kg/cm^2 in neutral.
  (c) Operate the engine at idling speed for about 10 minutes after starting to warm it up.

6-3 Operation & Stopping

(1) Shove in the clutch and check that the clutch oil pressure reaches the specified level. The oil pressure level falls during low speed operation, but this is not a problem.
(2) Shove in the clutch when the engine speed is below 1000 rpm for neutral → forward or reverse and also for forward ←→ reverse.
(3) During service operation, the oil temp. normally stabilizes at 50-80 ℃. However, the temp. is higher when clutch operation is frequent.
(4) Check for oil leakage and the oil level from time to time.
(5) Check for the abnormal sounds and excessive temp. rise. When trouble is suspected, stop the engine and locate the cause.
(6) Shift the clutch to neutral before stopping the engine.

6-4 Cautions for Single Unit Operation of Twin-Eng. Twin-prop. Unit and Towing

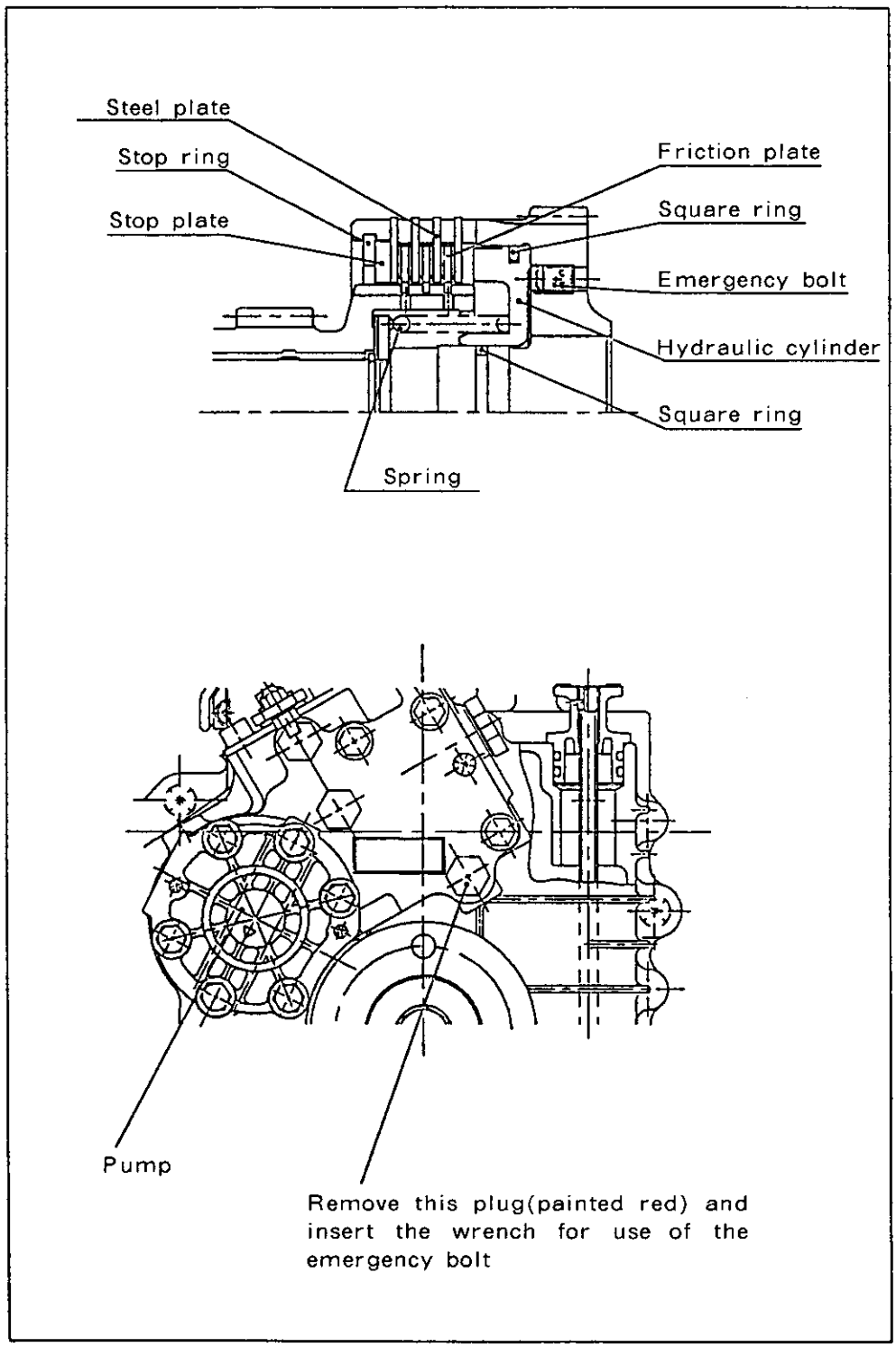
When the vessel is towed for a long time, the output shaft is rotated by the force of the propeller, causing the marine gear to be operated without lubrication. This can lead to trouble.
If the vessel is towed for more than one hour or if single unit operation of the twin-eng. twin-prop unit is necessary, fasten the propeller shaft to prevent it from turning. If this can't be done, it is necessary to disassemble and check each part (clutch, bearing, etc.) after the vessel has been towed to the port.

6-5 Cautions during Operation

Avoid the use of the clutch for long hours in the range where damper sounds or gear sounds are heard.

6-6 Emergency Clutch Repair

Should there be any trouble in the clutch, immediately stop the engine and provide proper measures as described in the Section on Troubleshooting. If the trouble can't be repaired, tighten the emergency bolt (no emergency bolt for the reverse clutch) with the accessory tool to connect to the clutch to enable the vessel to reach a port.



Handling of Emergency Bolt
(1) Stop the engine and remove the hexagon plug (with packing) of the case plate.
(2) Turn the flywheel to the position where the emergency bolt can be seen from the bolt hole.
(3) Insert the accessory wrench into the hole and tighten the emergency bolts.
Tighten the two emergency bolts evenly. The clutch is moved into forward by tightening the bolts.
(4) Install the plug which was remove to tighten the emergency bolts.
(5) After the clutch is connected, the vessel will move ahead when the engine is started. Be sure to shift the switch valve handle into neutral or forward. Operate the vessel with care since no halting or reversing is possible. Operate the engine within 3/4 load and be sure to avoid overloading. After returning to the port, disassemble the marine gear completely and repair the trouble. For re-use of the emergency bolt, turn the bolt in the reverse direction until it stops.
Before tightening the emergency bolts, supply lube oil up to the center of the support shaft.

7. Service Standard

7-1 Periodic Inspection

Check the marine gear periodically using to the following list.

Inspection interval	Check item	Procedure
Every day	Oil quantity	Insert oil dipstick fully before starting the engine
On oil exchange	Oil strainer	Clean
Every 5000 hours	Oil cooler	Clean inside the cooling pipe & cooler

7-2 Wear Limit of Major Parts

Unit: mm

Part	Measuring position	Wear limit	Procedure
Steel plate, Drive(driven)gear	Spline meshing backlash	1.0	Replace
Friction plate, Pinion	Same as above	0.5	Replace
Bush in pinion	Clearance to shaft	0.2	Replace
Friction plate	Thickness	2.6	Replace

7-3 Periodic Parts Replacement

Ball bearings	at 4-years periodic inspection
Packings	Replace all when disassembled
Rubber packings (O-rings,square rings)	Replace all when disassembled
Rubber block, Damper disc	at 4-years periodic inspection

8. Troubleshooting

Clutch Slips due to Abnormal Drop in Clutch Hydraulic Pressure

1	Check that there is no phase deviation of the remote control device.	
2	Is the oil level as high as specified?	
3	Is there abnormal wear in the gear pump?	
4	Is there oil strainer clogged?	
5	Are the switch valve and clutch hydraulic pressure control valve assembled correctly?	Refer to the parts diagram
6	Is the spring (clutch hydraulic pressure control valve) broken or has it collapsed?	Standard spring length: 50 mm
7	Is there stiffening of the control valve of the clutch oil pressure control valve?	Clean
8	Is the seal ring damaged or worn?	Clean or replace
9	Are the O-rings or square rings damaged or worn?	Replace

Abnormal Heat (Inspection is necessary when the oil temp. at the oil cooler inlet exceed 90 ℃.)

1	Does the clutch slip?	Refer to the section above
2	Does the oil level exceed the specified level?	Lower the oil level to the standard level
3	Is the bearing damaged? (Is any part of the gear case abnormally hot?)	Disassemble and check; replace if necessary
4	Are the piping or drilled holes clogged?	
5	Is there clogging in the oil cooler?	
6	Is there sufficient lube oil pressure?	

Lube Oil Pressurization Failure

1	Is there any oil leakage from each part?	
2	Is there piston stiffening of the lube oil pressure control valve, spring colapse or damage?	
3	Is the oil strainer clogged?	
4	Seal ring damaged or worn.	Replace

Dragging

1	Is there clutch seizure?	
2	Has the bush in the pinion seized?	
3	Has the clutch piston return spring collapsed or is it damaged?	Spring standard length: 45 mm

Forward and Reverse Changeover Failure

1	Clutch seizure(the cause is clutch slip; check the details the trouble.)	Replace
2	Is the remote control adjusted properly?	
3	Has the clutch piston return spring collapsed or is it damaged?	Refer to the above paragraph

9. Disassembly and Reassembly

9-1 Disassembly

Check for oil leakage from all parts before starting disassembly.
Drain the oil.
Before starting disassembly, also check for abnormal sounds from each bearing by turning the input shaft manually.

(1) Remove of Case Plate
- (a) Remove piping, remote control wires, etc.
- (b) Extract the output shaft coupling from the output shaft.
- (c) Remove the hydraulic pump.
- (d) Remove the starter (with bolts).
- (e) Remove all the case plate fixing bolts.

(Note that the knock pin is fitted to the case and case plate. Take care not to damage the shaft's seal ring.)

(2) Disassembly of Rotational Parts
- (a) Disassembly of Input Shaft and Support Shaft Ass'y
  - *Remove the bearing and bearing mount (engine side) from the shaft.
    The pinion assembly can be removed by removing the stop ring.
    (The stop ring is fitted inside the bearing mount. Do not pull out the pinion before removing this stop ring.)
  - *To disassemble the clutch, remove the stop rings of the drive gear and driven gear (engine side). Now, the friction plates and steel plates can be removed.
  - *The spring and hydraulic cylinder are removed by removing the stop ring at the middle of the shaft.
- (b) The out put shaft is easily disassembly by disassembling the case.
  [Note] The drive gear and driven gear are shrink-fitted to each shaft. Do not disassemble these gears.
- (c) Use the puller to remove the ball bearing from the case.(Warm the case in hot oil or water to facilitate removal.)

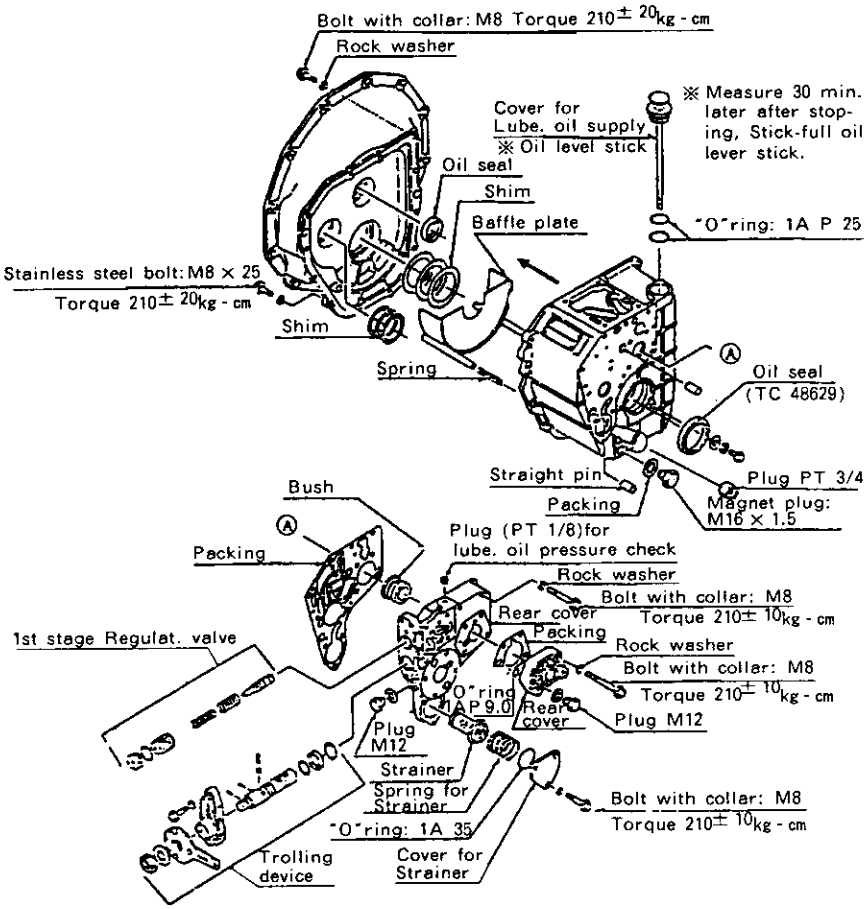
(YX6 Series Disassembly Procedures)

1. Remove all the pipings.
2. Place the clutch on the input shaft side on a work table. (Set the drive shaft free.)
3. Remove the switch valve and hydraulic pump assemblies.
   (Disassembly of Hydraulic Pump Ass'y)
   Hold the pump cover and lightly knock on the pump body with a copper or nylon hammer to disassemble. Take care not to damage the joint surface corners of the pump cover and case base.
   (Disassembly of Switch Valve Ass'y)
   Remove the main unit cover fastening bolts and remove the switch valve. (The spring and ball will fly out. Take care not to lose them.)
4. Remove the forward/reverse shaft rear cover.
   Remove the forward/reverse shaft seal ring.
5. Remove the output shaft rear cover and the case cover.
6. Remove the large gear assembly.
7. Remove the forward/reverse shaft assembly.
   (Forward/Reverse Shaft)
   Remove the inner race and thrust collar of the engine side bearing. Remove the stop ring and then the pinion ass'y can be removed.

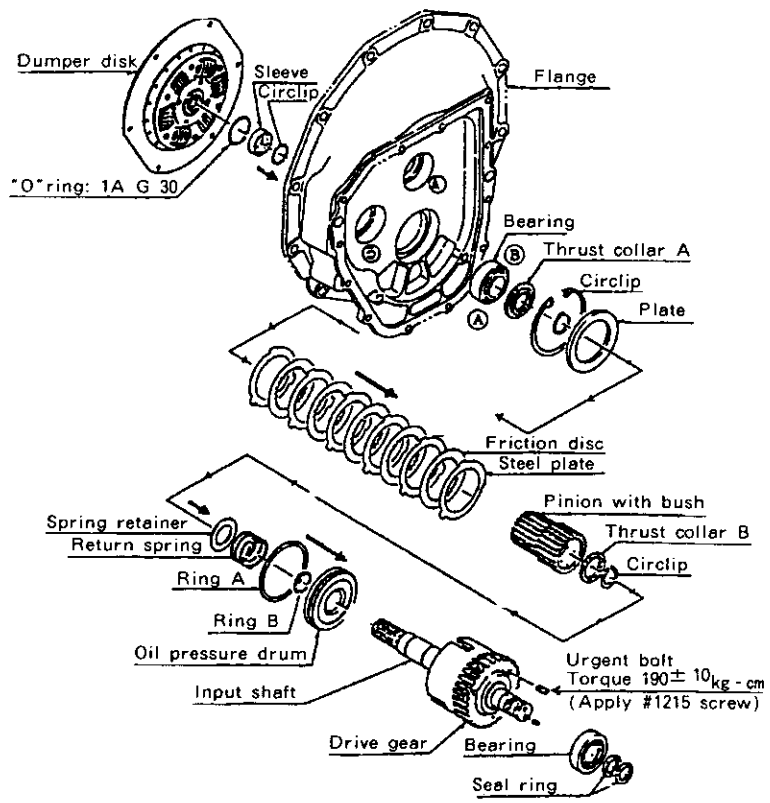
[Note]: To reassemble, follow to the disassembly procedures in reverse order.
Clean all parts completely before reassembly. Take care not to catch metal chips and not to damage the seat surface of the aluminum alloy case during reassembly.

9-2. Disassembly & Reassembly Procedures by Model

1. Clutch Case
   1) Apply THREEBOND #1215 to the joint surface of the case and flange and the threads of the emergency bolt before reassembly.
   2) Apply lithium grease to the oil seal, O-ring, square ring and seal ring.
   3) The three bolts at the bottom of the case are made of stainless steel.



2.Input Shaft (Support Shaft)
   1) Calk the stopper rings of the input shaft and support shaft (2 pcs. for each).
   2) Adjust Shim Thickness
      Input shaft -0.05 ~ +0.05
      Support shaft -0.05 ~ +0.05
   3) Apply lithium grease to the damper disc spline and end seal. Fill the lithium grease in the damper disc cap up to 40% of its space.

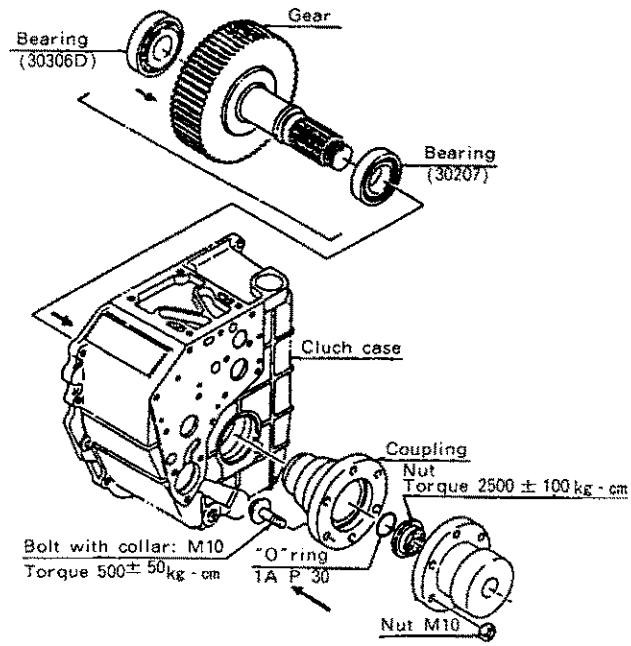


3. Output Shaft

1) Calk the finger nut stopper of the input shaft after tightening.

2) Adjust Shim Tightening Margin
Input shaft 0 ~ 0.1

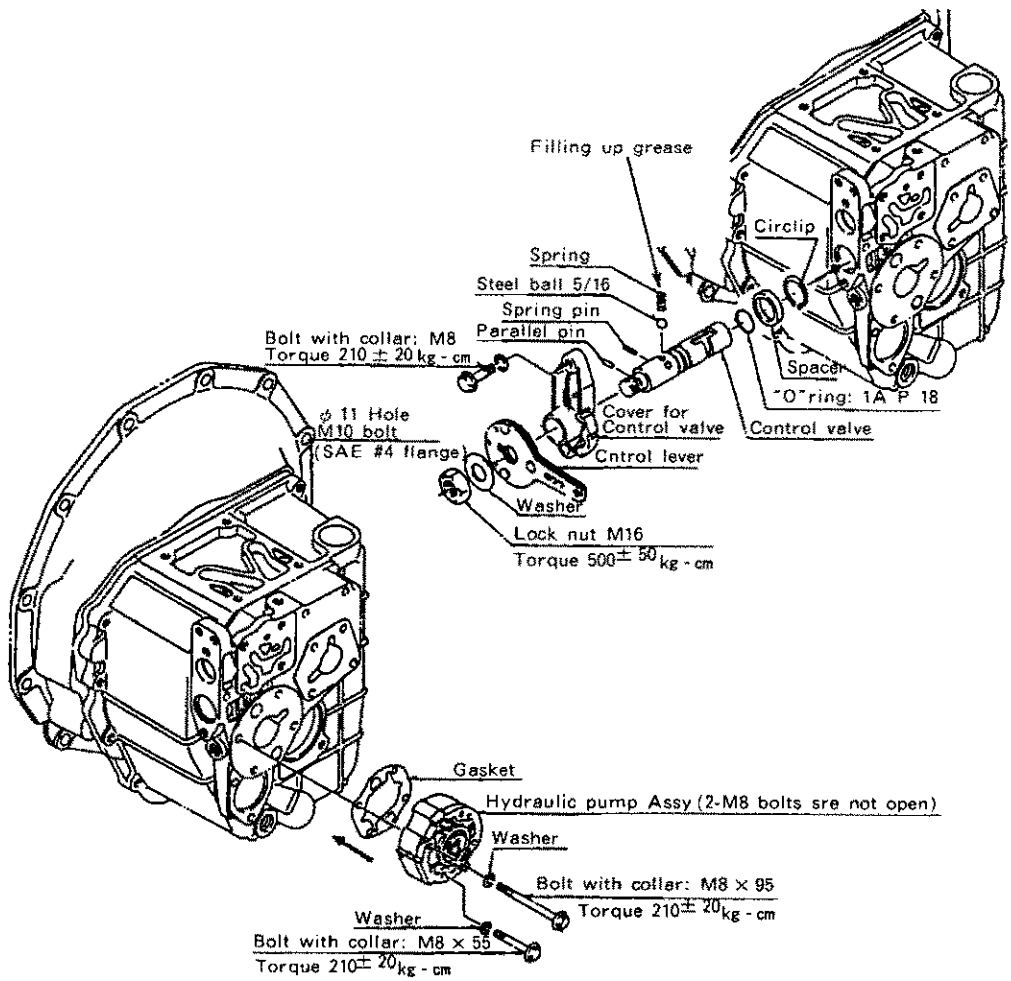
3) Take care not to reverse the oil seal lip while reassembling the input shaft coupling.



4. Hydraulic Pump, Switch Valve

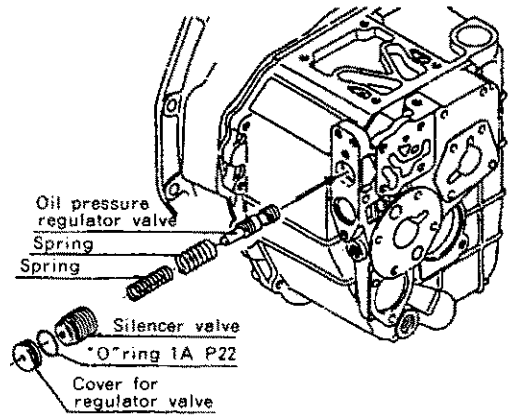
1) Clean oil holes and joint surface completely. Use new packings and O-rings.

2) Install the hydraulic pump in the direction as shown in the sketch.

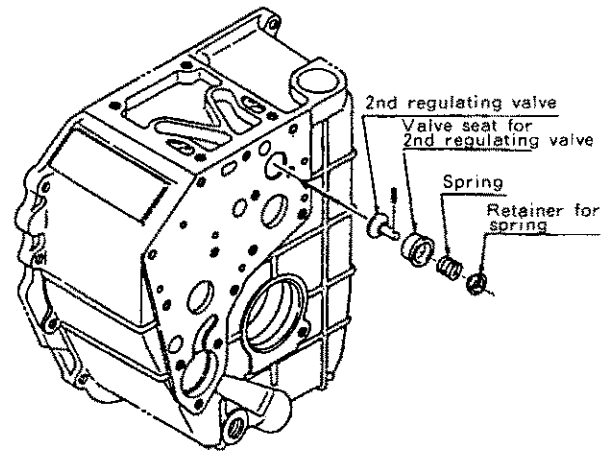


5. Primary Pressure Control Valve, Slow Engaging Valve.

1) Clean oil holes and disassembled parts completely.
2) Visually check for rust, flaws and cracks of the pressure control valve and spring.
3) Check if or not the pressure control valve moves smoothly.
4) Use new packings and O-rings.

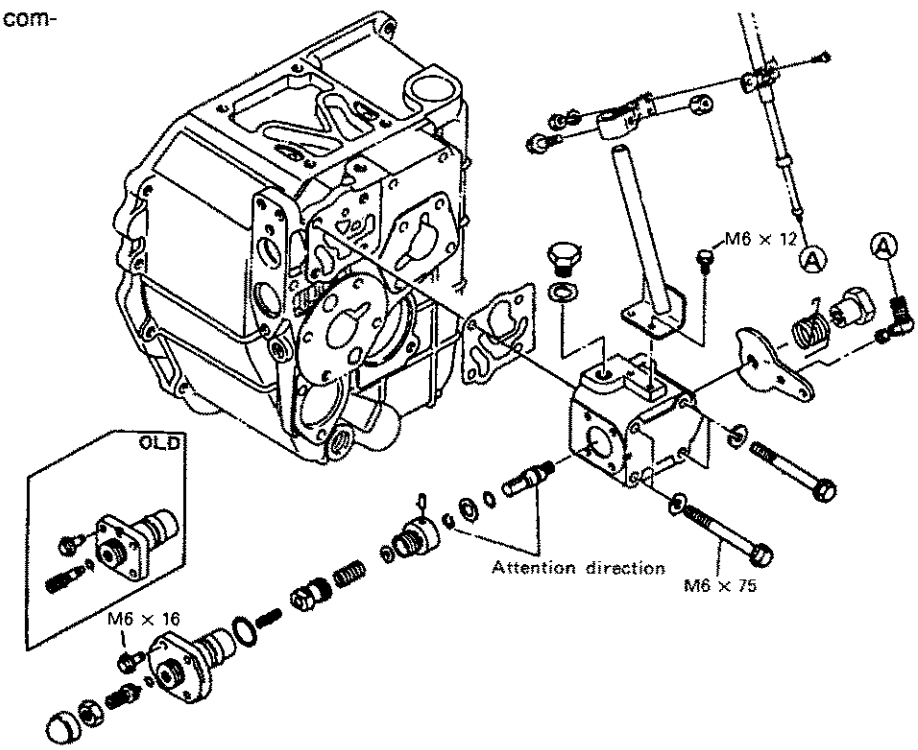


6. Secondary Pressure Control Valve

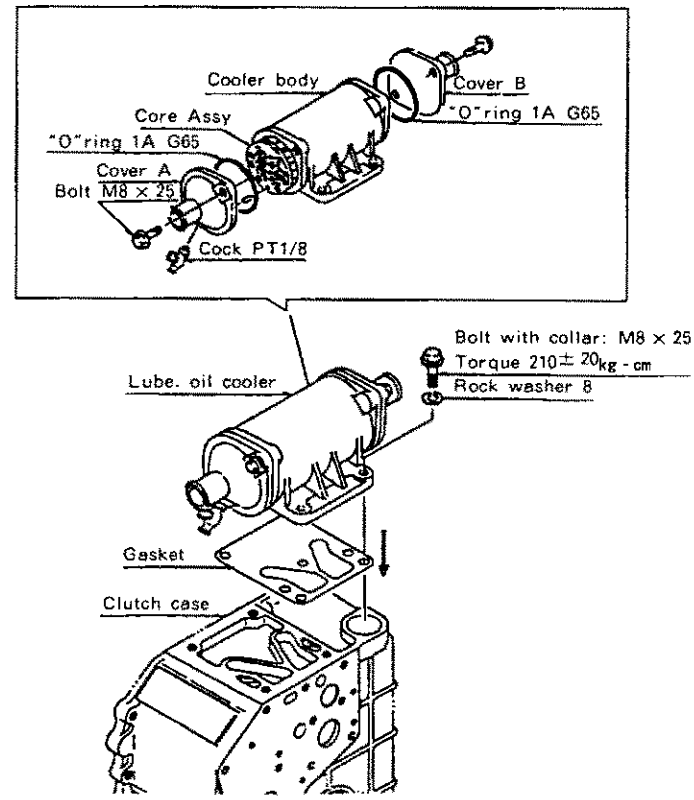


7. Slow Moving Valve

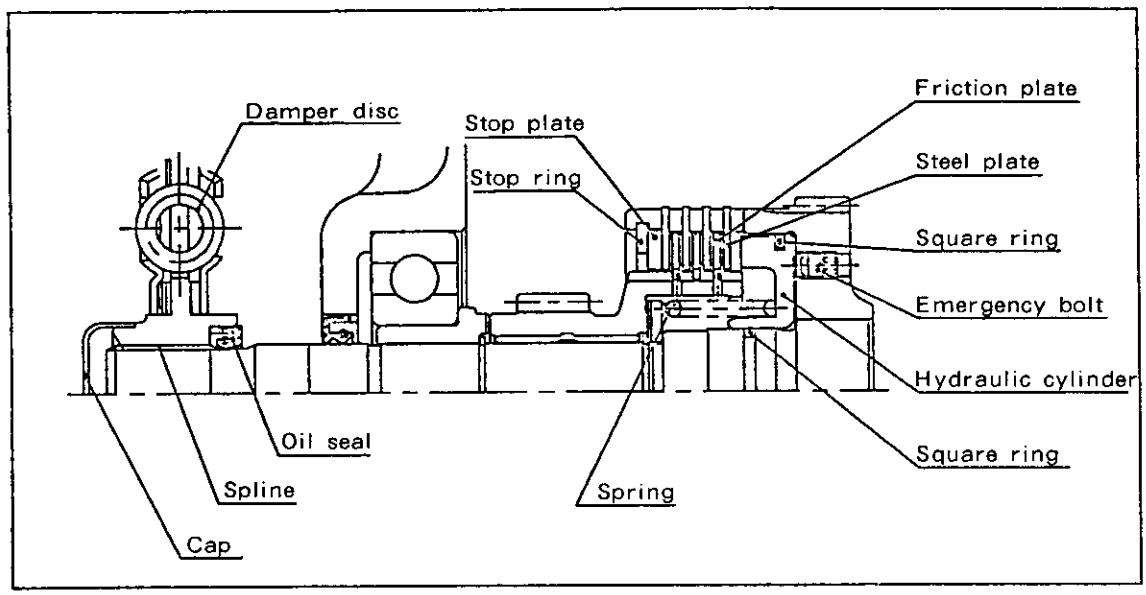
1) Clean oil holes and joint surface completely.
2) Use new O-rings.



8. L.O. Cooler
   1) Clean the cooling core completely.
   2) Use new O-rings.
   3) Apply THREEBOND #1215 to the joint surface of the L.O.cooler and case.



9-3. Reassembly



(1) Clean all part and take care not to let dust and metal chips get inside during reassembly. Reassemble in the reverse order of disassembly according to the following instructions.
(a) Replace parts with oil leaks and other faults. fore disassembly.
(b) Check for discoloration and abnormal wear to the bearing (listening for abnormal sounds). If faulty, replace the bearing.
(c) Replace parts which exceed the wear limit.
(d) Check the alignment marks for reassembly.
Be sure to install the hydraulic pump in the correct direction. Observe the △ mark on the external drawing.
(e) For rubber parts such as O-rings, either clean in cleaning oil or wipe off dust. Be sure to apply grease before reassembly.
(f) Replace all the packings.
(g) Tighten the bolts and nuts according to the specified tightening torque.
(h) Fasten the whirl-stop securely for all bolts fitted with one.
(i) It is recommended that the consumable parts such as O-rings, square rings, oil seals, stoppers (split pins, whirl-stop), etc. be replaced with new ones on every disassembly.
(j) Apply liquid packing (THREE BOND #1215) to the case and flange joint face.
(k) Check for oil leakage during operation soon after reassembly and re-tighten the bolts from time to time.

(2) Reassembly of Clutch
Be careful of the following points in clutch reassembly.
1. Apply grease to the square rings before assembling them to the hydraulic cylinder and shaft.
2. Take special care not to catch the square ring in the clearance when assembling the hydraulic cylinder.
3. Assemble the friction plates and steel plates by turns. When replacing the friction plate, soak the new friction plate in lube oil for more than 24 hours before installing it.
4. An extra steel plate is supplied in the friction plate and steel plate sets. There should be steel plate at both sides of each set.
(Note that the friction plate has the spline on the inside circumference.)

(3) Coupling with Engine
Take care of the following points when coupling the marine gear to the engine.
1. Fill the inside of the cap at the tip of the damper disc with lithium grease to 40 % of its volume, (approx. 1500 cc).
2. Apply lithium grease to the damper disc spline and oil seal.

9-4. List of Tightening Torques

Tightening Positions

Tightening position	Bolt dia. × pitch	Tightening torque N−m(kgf−m)	Remarks
Output shaft coupling fixing bolts	M14×1.5	196±9 (20±1)	Apply grease to the threads and seat
Emergency bolt	M6×1.0	4.9±1 (0.5±0.1)	Apply # 1215 to the threads
Hydraulic pump fixing bolts	M8×1.25	20.6±1 (2.1±0.1)	
SUS bolts below the case	M8×1.25	20.6±2 (2.1±0.2)	
Switch valve lever fixing bolt	M8×1.25	25.5±1 (2.6±0.1)	
PT plug	PT 1 / 8	9.8±1.0 (1.0±0.1)	
Hexagon head plug	M12×1.25	29.4±2.0 (3.0±0.2)	
	M16×1.5	53.9±4.9 (5.5±0.5)	

Standard Tightening Torque (7T bolt)

Bolt dia × pitch		M6×1.0	M8×1.25	M10×1.5
Tightening torque N−m(kgf−m)	Tightened material: aluminum	8.8±1.0 (0.9±0.1)	20.6±2 (2.1±0.2)	39.2±2.0 (4.0±0.2)
	Tightened material: FC or steel	10.8±1.0 (1.1±0.1)	25.5±2 (2.6±0.2)	49.0±4.9 (5.0±0.5)

APPENDIX

1. Storage Standard

(1) Place for Storing the Bare Unit
(a) Store the unit on the an indoor concrete floor.
(b) The storage place should be free from dust.
(c) Do not store the unit near places that may be damp.
(d) Do not store the unit near places that may have high humidity or hot air.

(2) Cautions for Storing Bare Unit (include. inboard unit with anti-rust treatment)
(a) Apply anti-rust oil inside the marine gear every 6 months.
(Feed anti-rust oil to the specified amount. Turn the input shaft ten times in its normal turning direction. Turn the output shaft clockwise and counterclockwise ten times each. Then drain the anti-rust oil.)
(b) When the unit is left unused for over a year, overhaul it.

(3) Storage Onboard (with hydraulic oil)
(a) When the marine gear is left onboard, operate the unit at least once in 3 months to send oil to each part.
(b) When the unit is left onboard for more than a year, overhaul it.

(4) Storage of Parts (Be sure to store the parts indoors.)
(a) Handle bearing, gears and other parts which may rust with care. Do not touch these parts directly with your hand. If they have to be touched or oil must be wiped off them, be sure to re-apply anti-rust oil.
(b) Be sure to put electrical equipment and other parts which may be damaged by moisture into a vinyl bag and store it on a dry shelf.
*Put O-rings, oil seals and other rubber parts which may degenerate into a vinyl bag for storage.
*Do not use O-rings, oil seals and other rubber parts which have been left unused for more than 2 years from the date recorded on the inspection list in the vinyl bag.

2. Parts to be Replaced Periodically

(1) The Maritime Safety Law requires inspection of the following:
*Intermediate Inspection: gear face and main thrust bearings
*Fixed Term Inspection: overall disassembly and inspection

(2) Rubber parts, packings, bend washers, etc. must be replaced after disassembly.

(3) Replace all parts which are expected to be damaged due to fatigue by the time of the next fixed term inspection. In order to prevent trouble, we have prepared the following list based on our past experience of repair and parts replacement. The list, however is only to be used as a standard reference for parts replacement. It may also be necessary to replace parts not included in the list depending on the results of the inspection. We prepared parts lists (with parts numbers) by model and are ready to deliver the parts necessary for the intermediate and fixed term inspections immediately upon being advised of the manufacturing number of your marine gear.

Interval / Item	Replacement interval		Remarks
	2 Years	4 Years	
Square ring	○	○	Hydraulic cylinder
Seal ring	○	○	Input & support shafts
Packing	◎	○	
O-ring	◎	○	
Oil seal	◎	○	Input & output shafts
Copper packing	◎	○	
Damper disc	※	○	
Stop ring	※	○	Hydraulic cylinder
Spring	※	○	Hydraulic cylinder
Friction plate	※	○(Forward only)	
Steel plate	※	○(Forward only)	
Bush metal	※	※	Pinion gear
Needle bearing			Hydraulic oil pump
Orudum joint			
Pump dry sleeve & pin			Hydraulic oil pump
Hydraulic oil pump ass'y	※	※	Hydraulic oil pump

○: Replace
◎: Replace whenever disassembled (even within 2 years).
※: Replace depending on the condition of parts
Replace bearing at fixed term inspections.

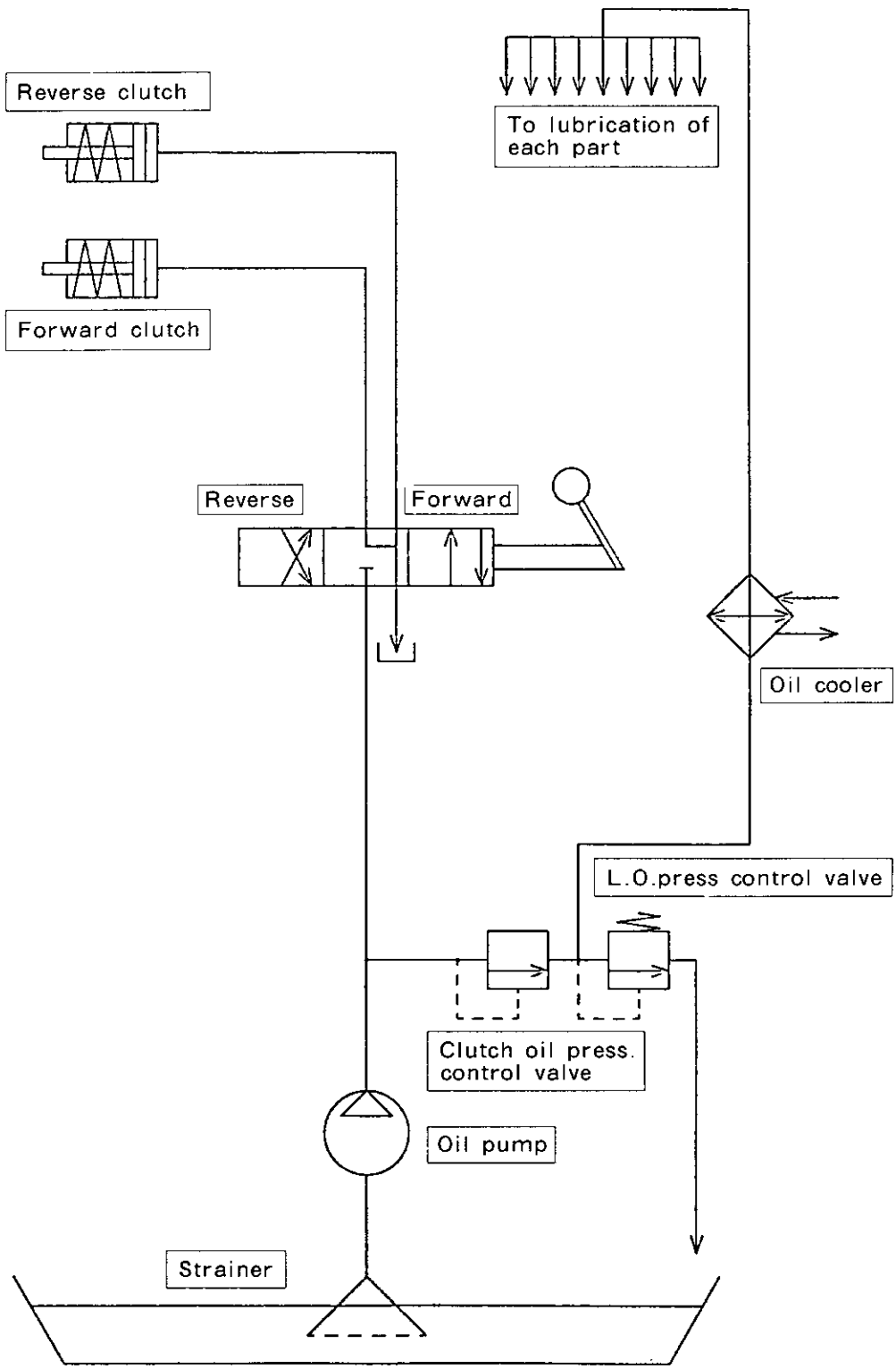
3. Recommended Marine Gear Oil

The marine gear oil is used as both the clutch hydraulic oil and lubrication oil. The oil should be stable against temp. changes, superior in acid-and water-resisting characteristics and should have no adverse effect on gears, friction plates and other materials.

Recommended Oil Brands

Idemitsu Kosan	Daphne Marine Oil SX30
Esso Standard Oil	Tromer SD30
Caltex	R.P.M DELO Marine Oil 30
Kyodo Oil	Kyoseki Marine D13
Showa Shell Oil	Merina S Oil 30
General Bussan	Gemico Marine DX103
Mitsubishi Oil	Diamond Marine T103
Mobile Oil	Mobile Guard 312
Nihon Oil	MDL Oil UX30
Nichimo Oil	Kignas Marine DX30
Cosmo Oil	Cosmo Marine 3005

4. Reduction Reversing Gear Hydraulic Oil Diagram (YX-6)



CHAPTER 8

DISASSEMBLY AND REASSEMBLY

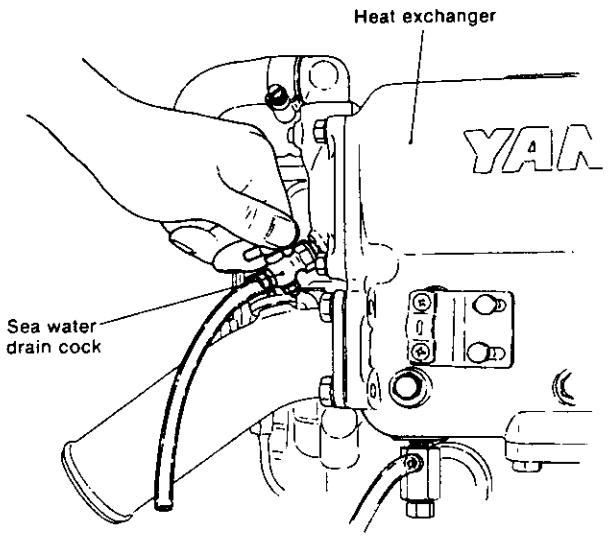
1. Disassembly of Fresh Water-Cooled Engine 8-1
2. Reassembly of Fresh Water-Cooled Engine 8-11
3. Accessaries 8-18

1. Disassembly of Fresh Water-Cooled Engine

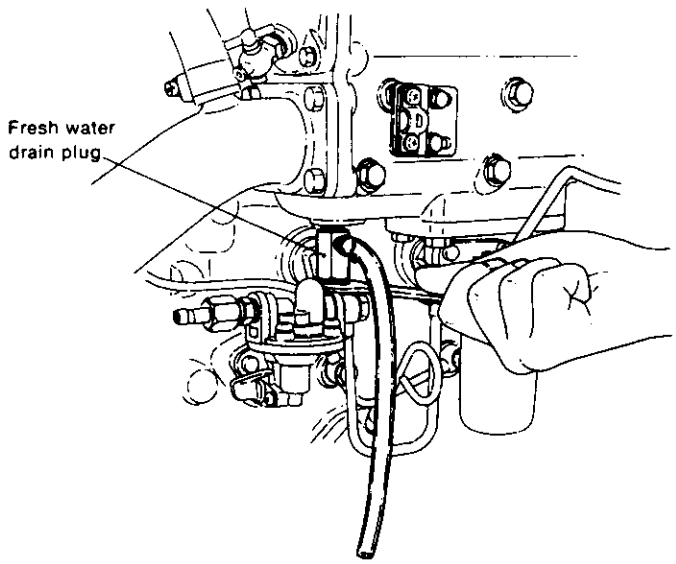
In general, the disassembly sequence for a fresh water-cooled engine is the same as that for a sea water-cooled engine, except that the sequence for parts related to the cooling water system are slightly different. Refer to the disassembly section of the sea water-cooled engine manual for the latter steps.

1-1. Draining the cooling water

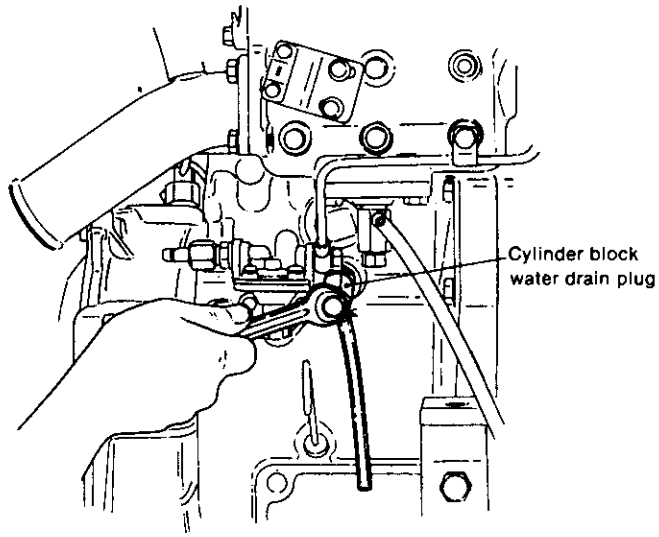
(1) Drain the sea water from the heat exchanger. The sea water drain cock is installed on the side cover of the heat exchanger at the rear.

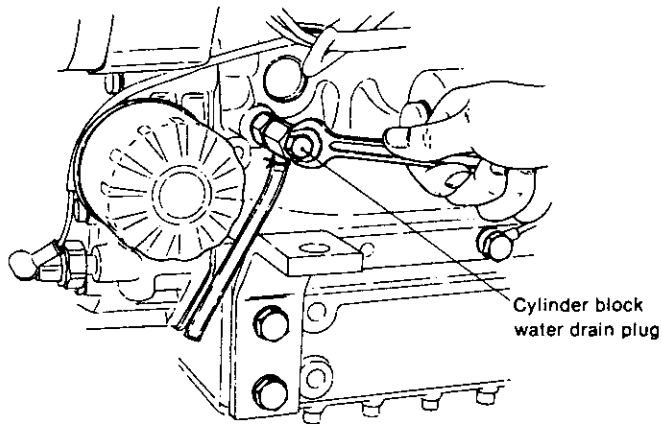


(2) Drain the fresh water from the heat exchanger. Loosen the fresh water drain plug installed at the bottom of the heat exchanger.

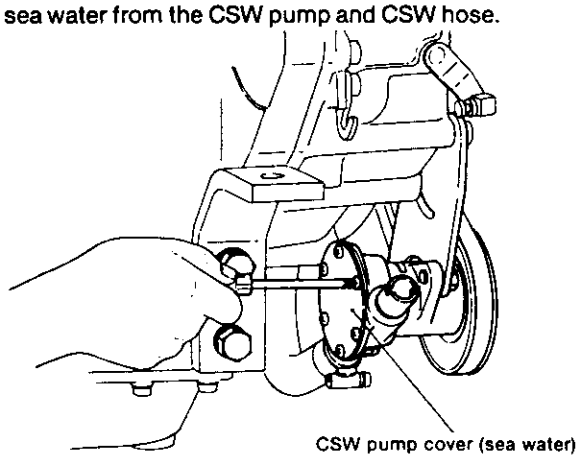


(3) Drain the fresh water from the cylinder block.
Loosen the cylinder block water drain plug and drain the fresh water. The water drain plug is installed on the block wall surface at the exhaust side in a model 2GMFY engine, and on the block wall surface at the intake side in models 3GMFY engines.





(4) Draining sea water from the CSW pump
Loosen the CSW pump cover fixing screws, and drain the sea water from the CSW pump and CSW hose.

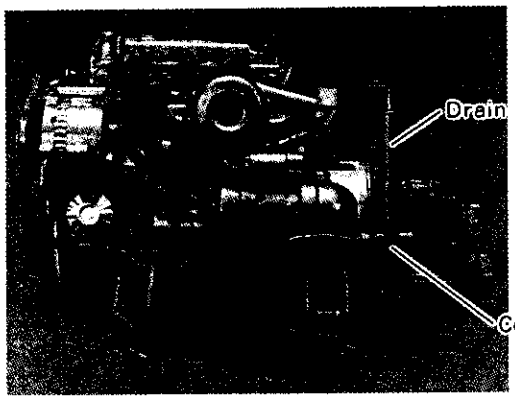


NOTE: CSW = Cooling Sea Water

1-2. Drain the lubricating oil

(1) Engine side

Turn to engine side of the cock, and pump out the oil with a waste oil pump with cylinder.

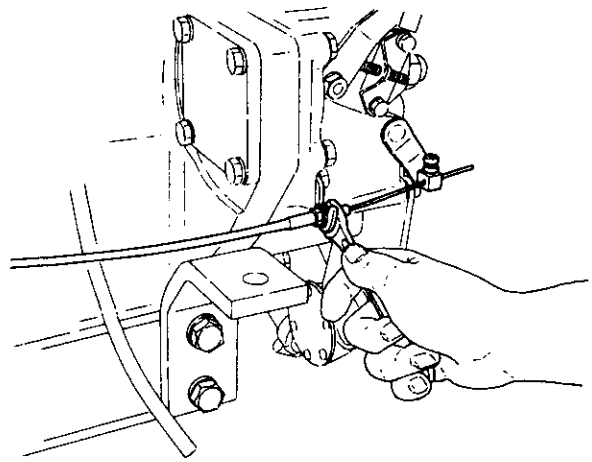


(2) Clutch side

Turn to marine gear side to the cock, and pump out the oil with a waste oil pump.

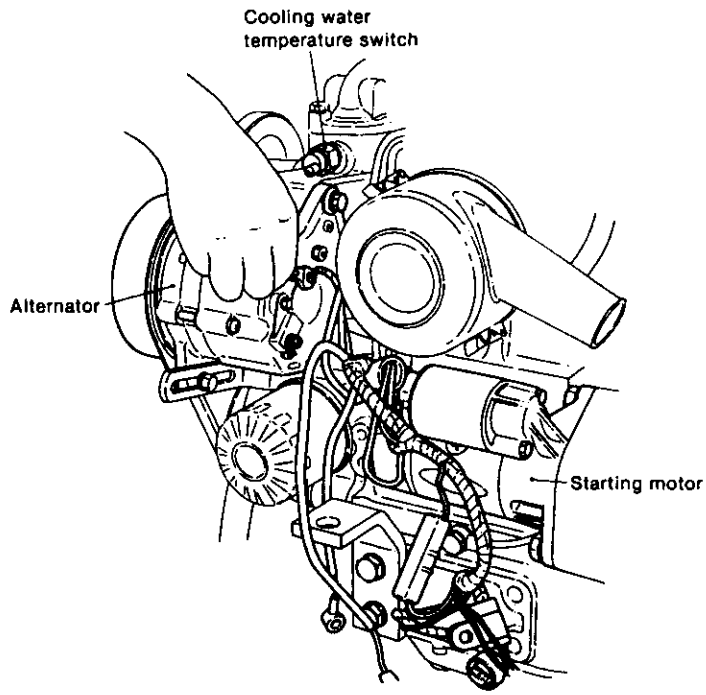
1-3. Disconnect the remote control cables

(1) Clutch remote control cable
(2) Speed remote control cable
(3) Engine stop remote control cable
(4) Decompression remote control cable



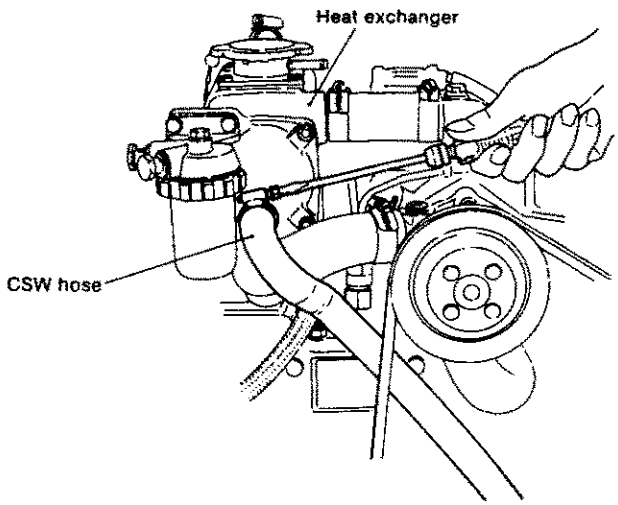
1-4. Disconnect the electrical wiring

(1) Alternator wiring
(2) Starter motor wiring
(3) Water temperature switch wiring
(4) Oil pressure switch wiring
(5) Tachometer sender wiring



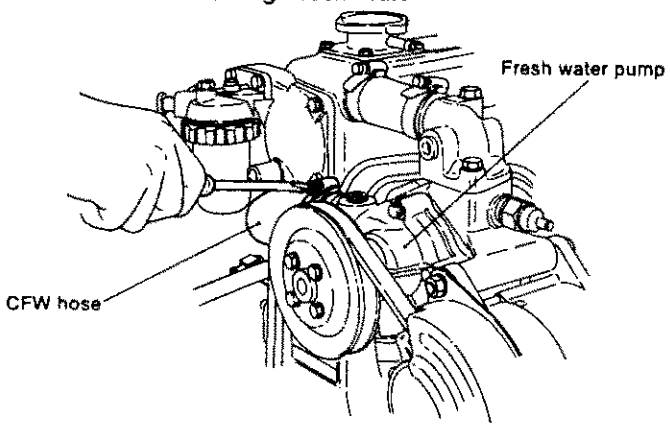
1-5. Remove the CSW hose

(1) Remove the CSW hose between the CSW pump and heat exchanger.

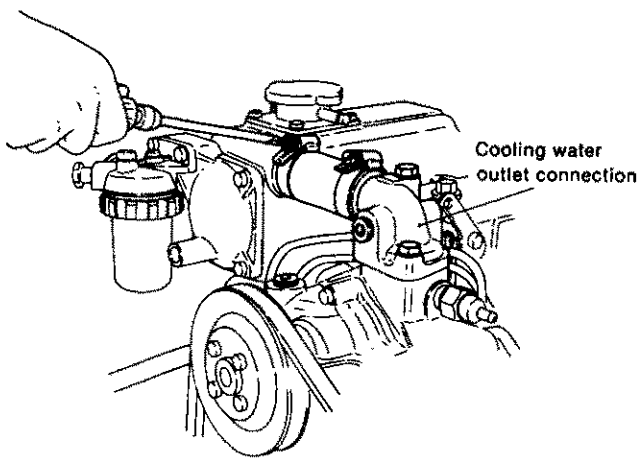


(2) Remove the CFW hose between the heat exchanger and CFW pump.

NOTE: CFW = Cooling Fresh Water

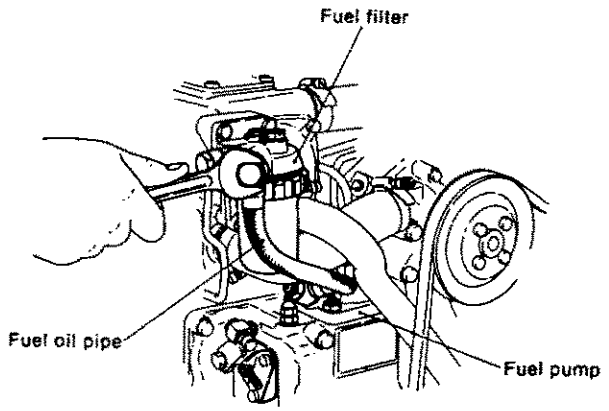


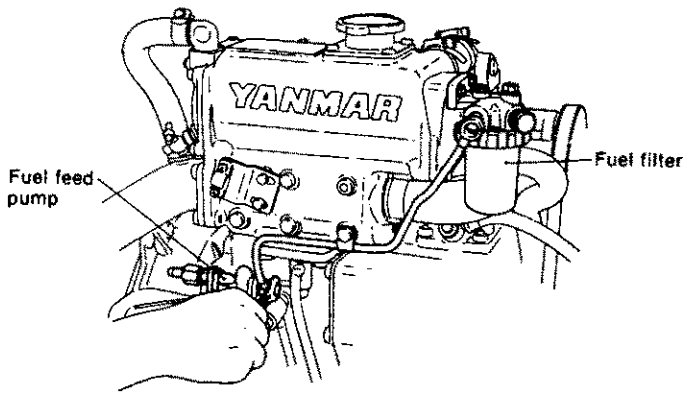
(3) Loosen the hose clamp on the CFW hose between the cylinder head and heat exchanger. The hose clamp at the heat exchanger side or the cooling water outlet connection side only need be loosened.

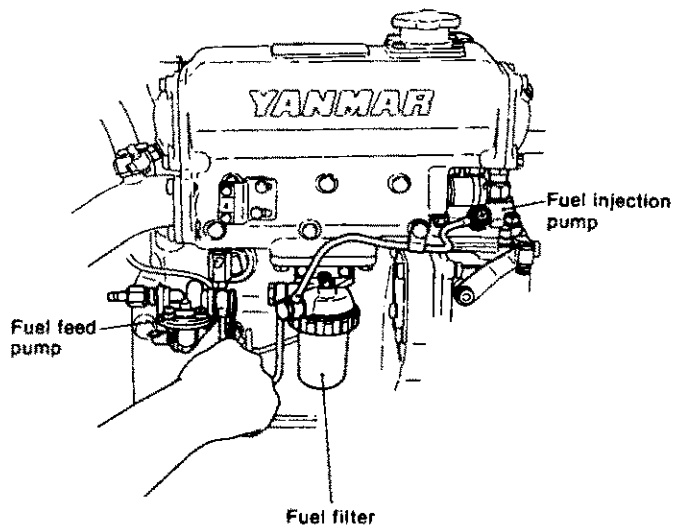


1-6. Disconnect the fuel piping

(1) Fuel tank to feed pump
(2) Feed pump to fuel filter
(3) Fuel filter to fuel injection pump

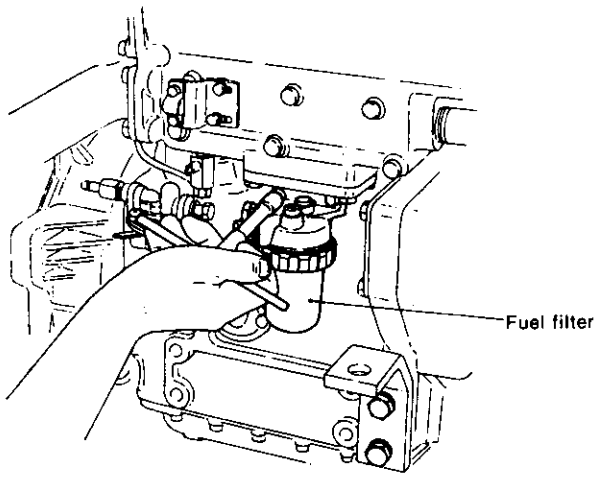






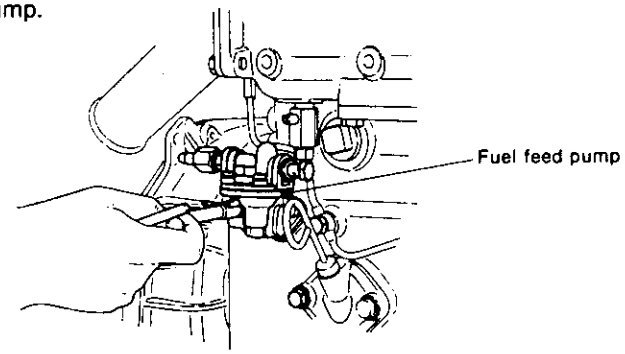
1-7. Removing the fuel filter

The fuel filter can be removed as assembled to the heat exchanger. However, to make removal of the heat exchanger easier, the filter should be removed separately.



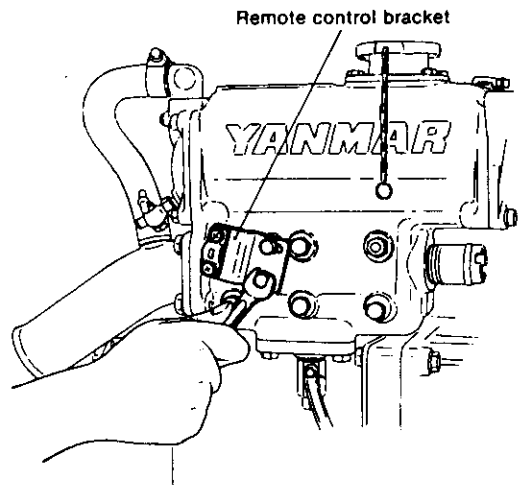
1-8. Remove the fuel feed pump

In cases of model 3GMFY, the heat exchanger drain plug may jam against the fuel feed pump pipe connecter. The fuel feed pump should be removed before removing the heat exchanger.
In cases of models 2GMFY , the heat exchanger can be removed without removing the fuel feed pump.

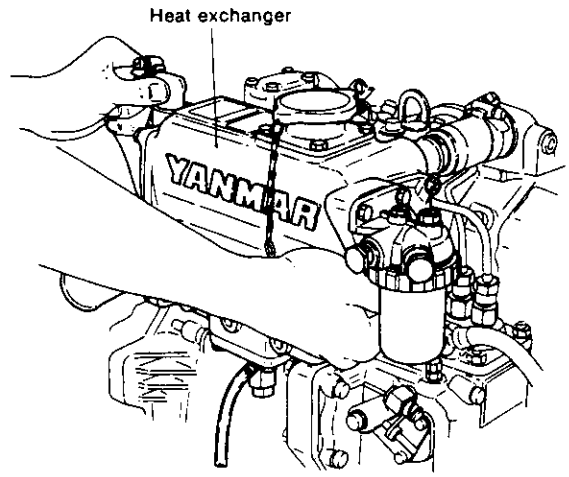


1-9. Remove the remote control bracket

The heat exchanger fixing nut cannot be removed without first removing the remote control bracket.

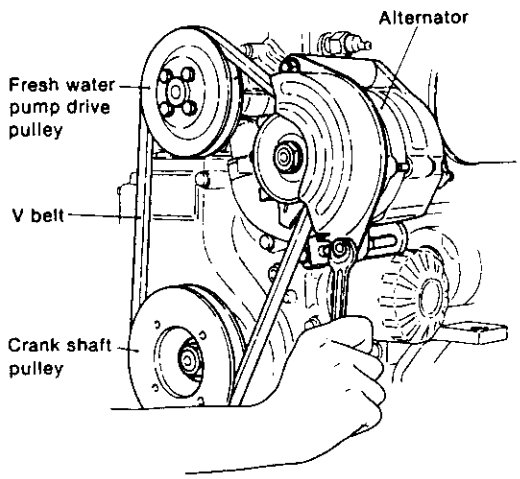


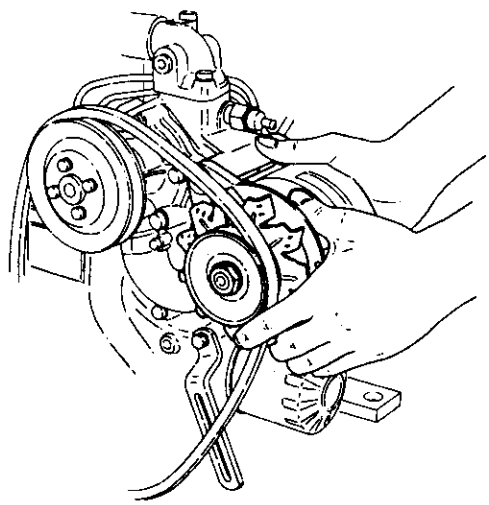
1-10. Remove the heat exchanger.



1-11. Remove the alternator

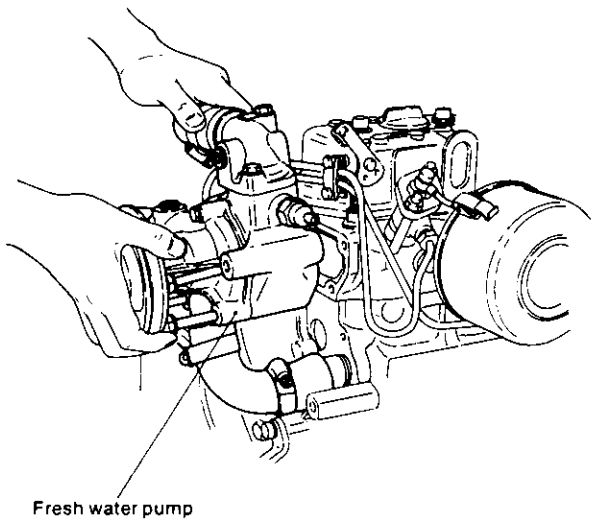
(1) Loosen the adjusting bolt and remove the V-belt
(2) Remove the alternator





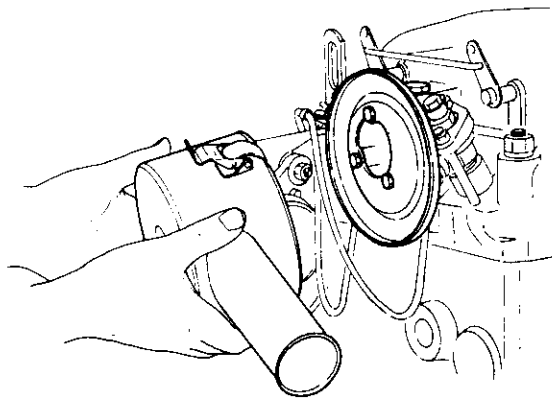
1-12. Remove the CFW pump

Remove the CFW pump by loosening the hose clamp on the CFW hose between the CFW pump and cylinder block at the cylinder block end.

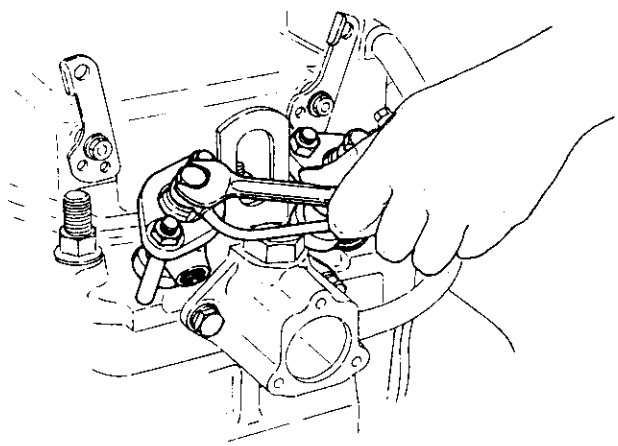


1-13. Remove the air intake silencer

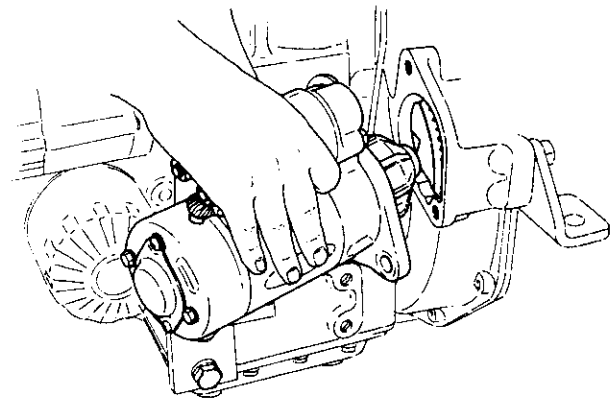
Remove the intake silencer clip and the filter element. Then remove the set screw and the cover.



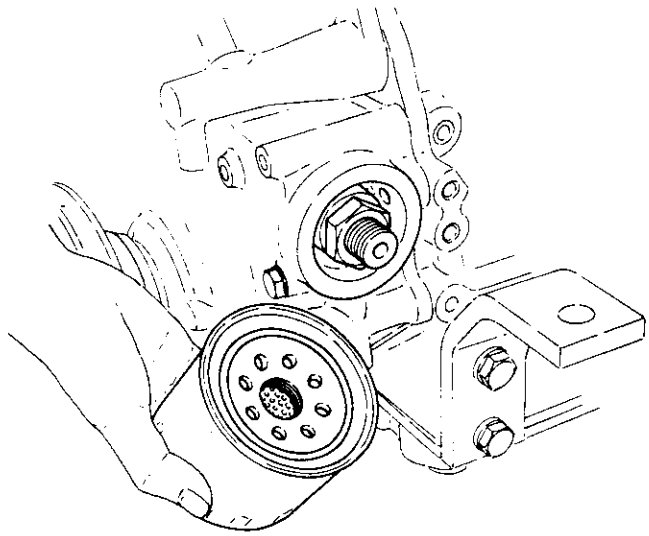
1-14. Remove the fuel high pressure pipe and fuel return pipe.



1-15. Remove the starter motor

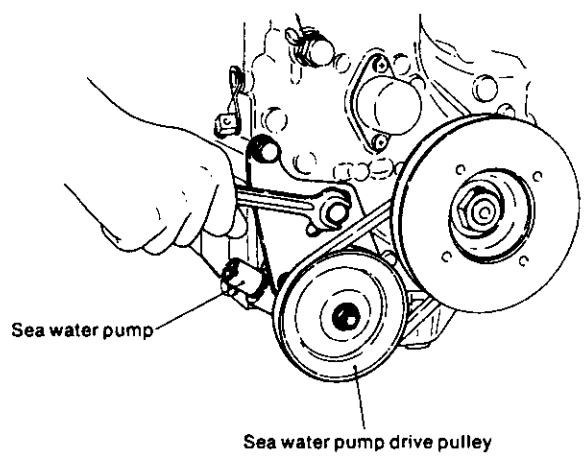


1-16. Remove the oil filter



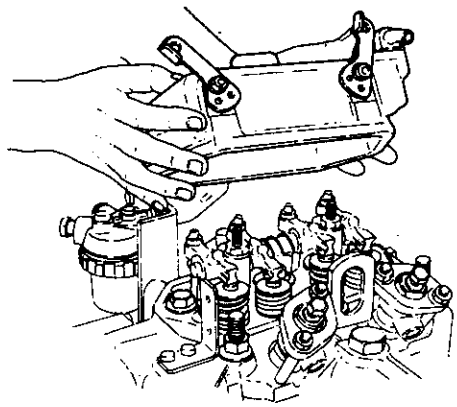
1-17. Remove the CSW pump

Loosen the water pump mounting bolts, remove the V-belt by sliding it toward the crankshaft side, and remove the sea water pump.



1-18. Remove the rocker arm chamber

(1) Remove the breather pipe at the side of the intake pipe [intake manifold for model 3GMFY
(2) Remove the rocker arm chamber



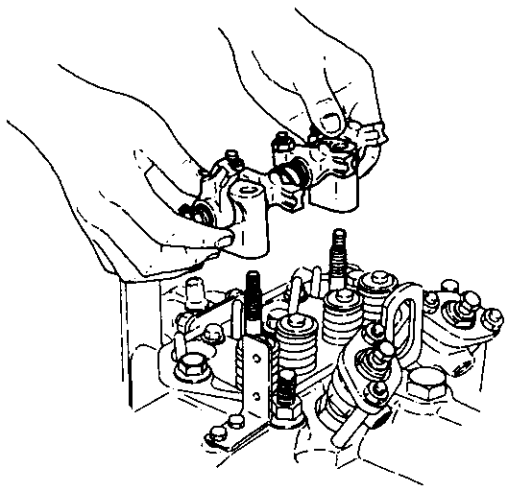
After this step disassembly is carried out in the same sequence as for the sea water-cooled engine.

The details are given in Section 4.3.14 "Remove the rocker arms." P12-23 of the sea water-cooled engine manual.

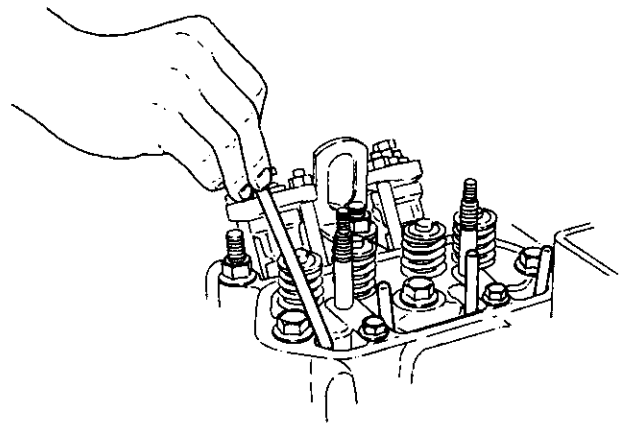
For reference

1-19. **Remove the rocker arms**

(1) Remove the mounting nut and remove the rocker arm shaft assembly.



(2) Pull the push rods.

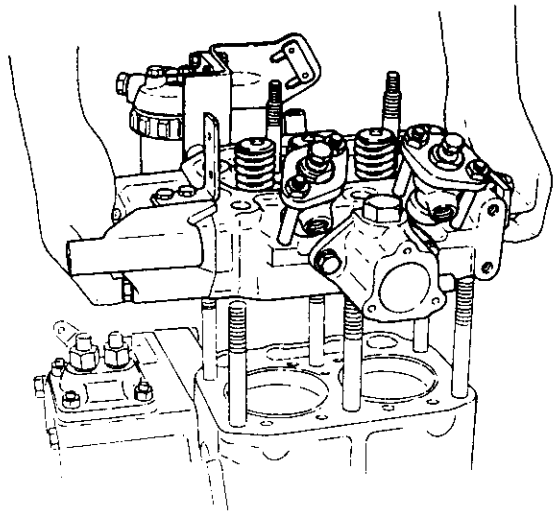


(3) Remove the cotter pins of the intake and exhaust valve springs.

NOTE: Arrange the parts by cylinder no., intake and exhaust.

1-20. **Remove the cylinder head**

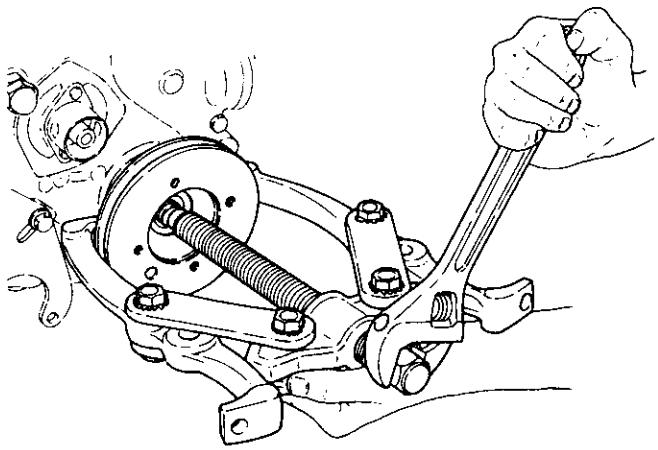
(1) Disconnect the lubricating oil pipe.
(2) Remove the cylinder head nuts in the prescribed order, and remove the cylinder head.
(3) Remove the gasket packing.



NOTE: Clearly identify the front and back of the gasket packing.

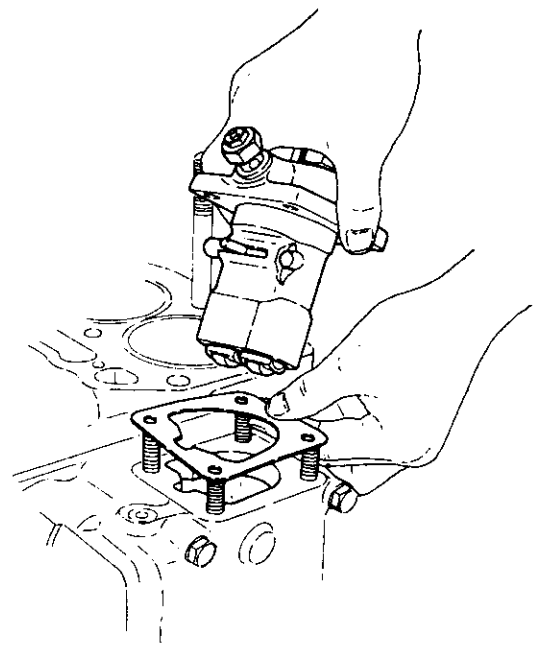
1-21. **Remove the crankshaft pulley**

Remove the crankshaft pulley end nut and remove the V-pulley and key.



1-22. **Remove the injection pump**

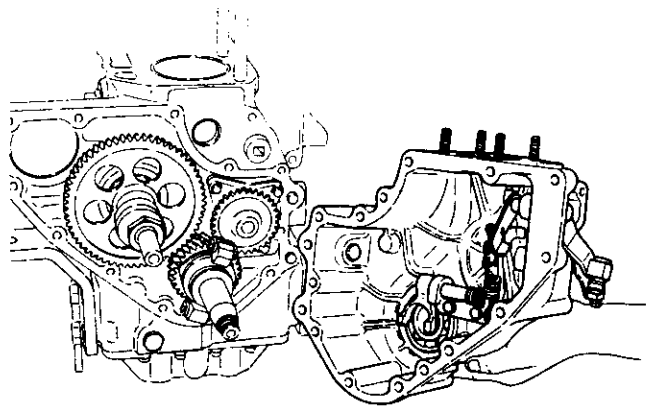
(1) Remove the injection pump nut.
(2) Remove the gear case side cover, move the governor lever 2, take out the fuel injection pump by matching the control rack with the cut-off part of the gear case.



(3) Remove the injection timing adjustment shims.
CAUTION: Note the number and total thickness of the timing adjustment shims.

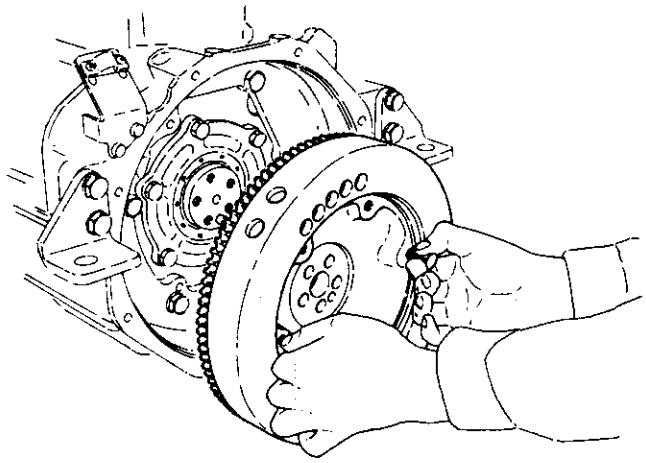
1-23. **Remove the timing gear case**

(1) Remove the gear case

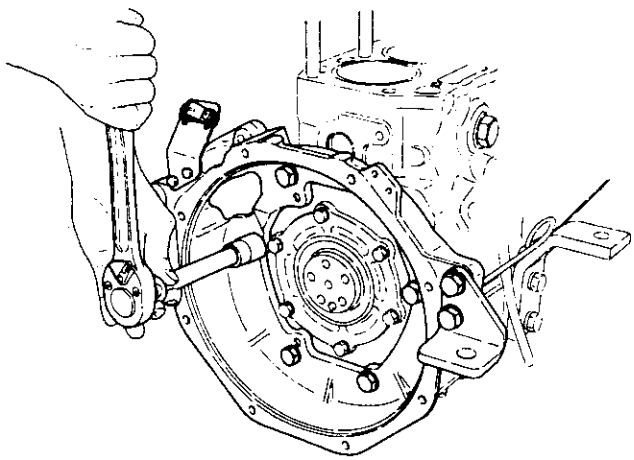


(2) Remove the thrust collar, thrust needle bearing, and governor sleeve.

1-25. Remove the flywheel.
Screw-in the two bolts to secure the clutch disk (slightly to the left and right sides of the flywheel) and remove it by pulling on the bolts.

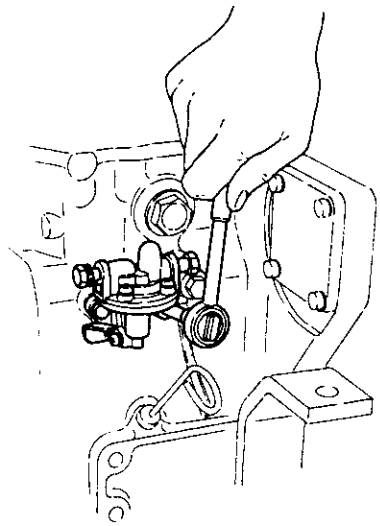


1-26. **Remove the flywheel housing**



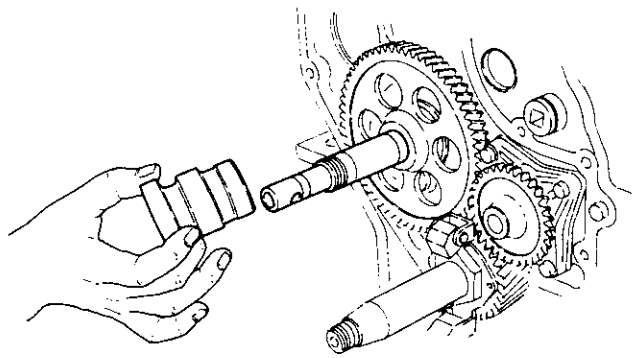
1-27. **Remove the lubricating oil dipstick**

1-28. **Remove the feed pump**

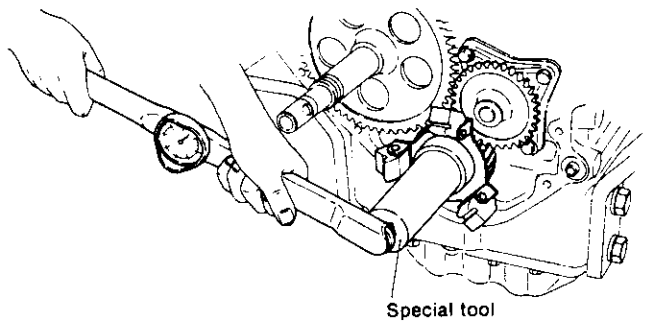


1-29. **Remove the fuel cam**

Remove the camshaft end nut and remove the fuel cam.

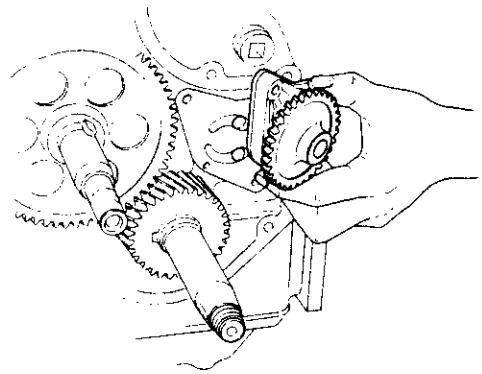


1-30. Remove the governor weight assembly

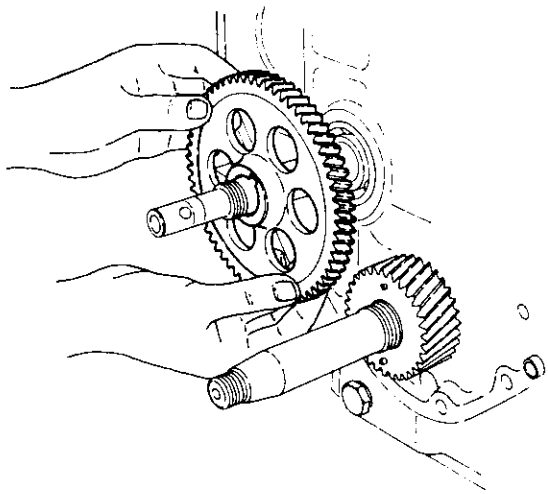


Remove the crankshaft end nut and remove the governor weight assembly.

1-31. Remove the lubricating oil pump and driving gear assembly



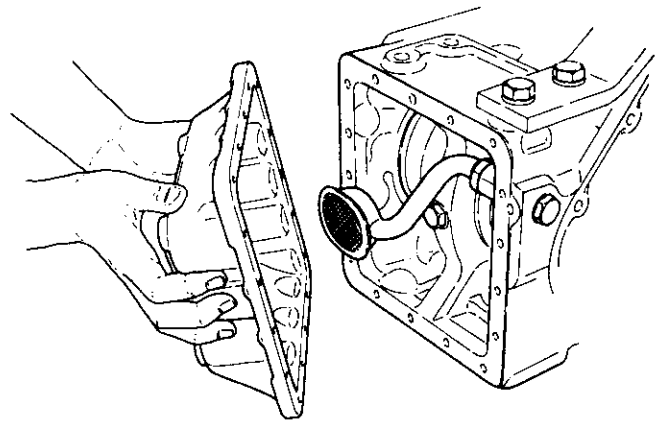
1-32 Remove the camshaft gear and the crankshaft gear



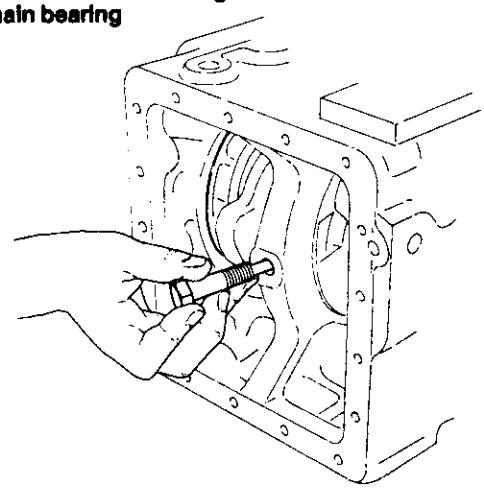
1-33. Turn the engine onto its side

(1) Remove the engine feet of the crankshaft side
(2) Turn the cylinder block over so that the crankshaft side is on the bottom.

1-34. Remove the oil pan and the oil intake pipe

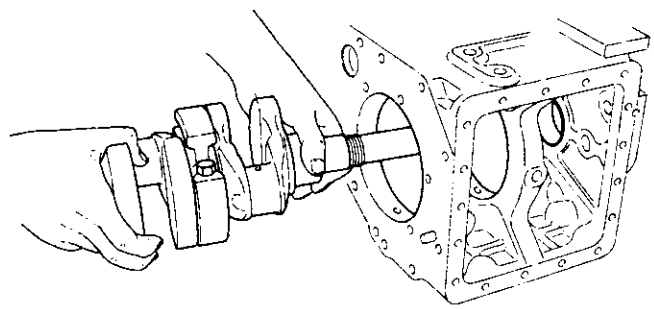


1-35. Remove the mounting bolt of the intermediate main bearing



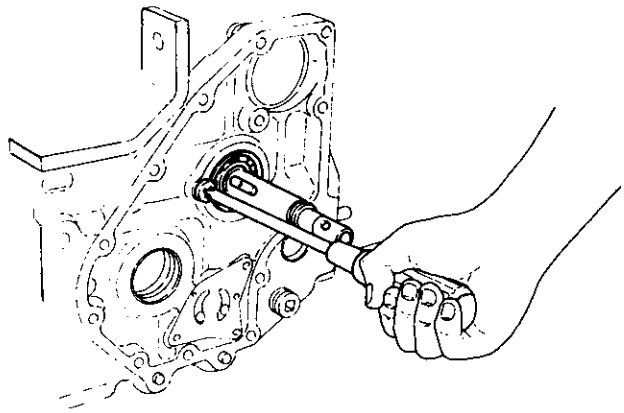
There are two intermediate main bearings, viz. No.1 and No.2, for engine model 3GMFY.

1-36. Pull the crankshaft

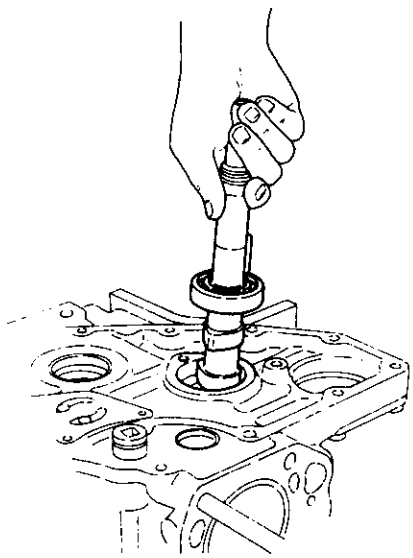


1-37. **Remove the camshaft**

(1) Remove the camshaft bearing set screw.

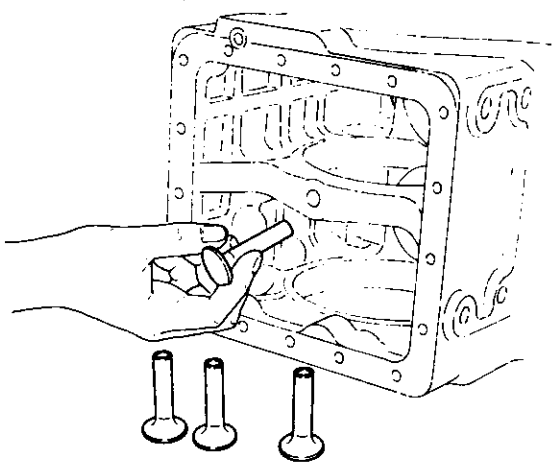


(2) Place the cylinder block upside down or raise the cylinder block by inserting a plate beneath it in order to prevent contact between the tappet and the cam.



(3) Check that all the tappets are separated from the cam, and pull the camshaft out.

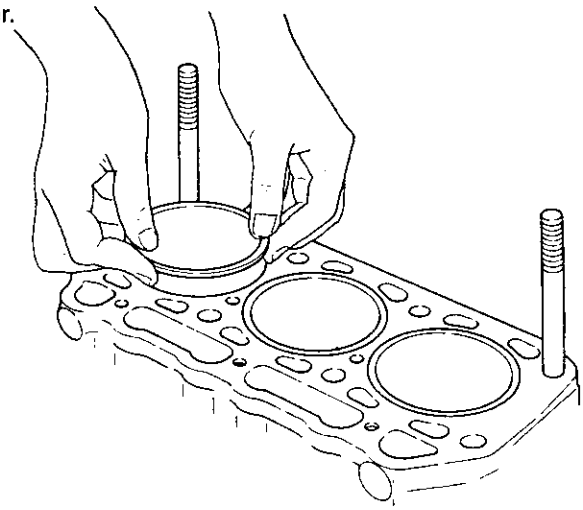
1-38. **Remove the tappets**



NOTE: Arrange the removed tappets by cylinder no. and intake and exhaust groups.

1-39. **Remove the liners**

Set the engine upright and pull the liners with a liner puller.



2. Reassembly

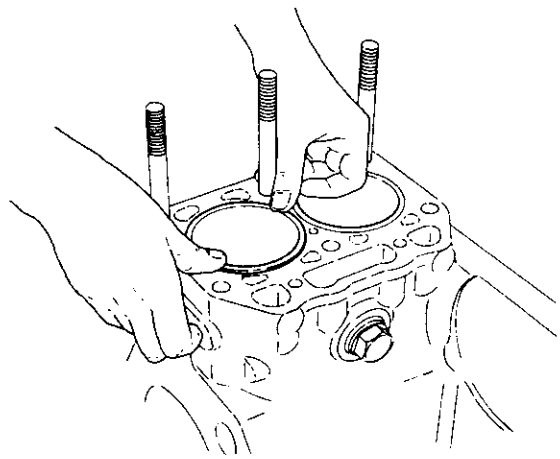
In general, the reassembly of the fresh water-cooled engine is the same as that for a sea water-cooled engine, except for cooling system components such as the heat exchanger, fresh water pump, cooling water pipe and related parts.

For details of the first half of the reassembly sequence refer to the sea water-cooled engine manual, Sections 5-3.1, P12-35 to 5-3.24, P12-41.

For reference

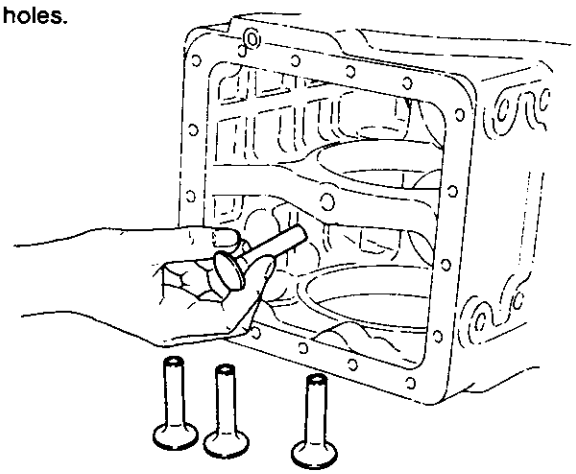
2-1. **Assemble the cylinder liners**

(1) Remove any rust from the cylinder block where it contacts the cylinder liners.
(2) Coat the outside periphery of the liners with waterproofing paint.
(3) Insert the liners into the cylinder block, making sure that the cylinder liner protrusion is correct.



2-2. **Insert the tappets**

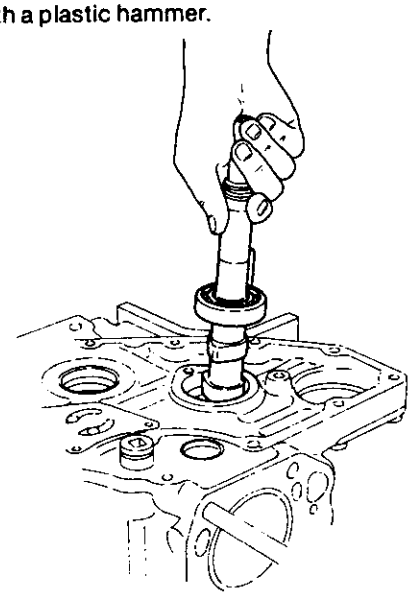
(1) Turn the cylinder block over or turn it upside down.
(2) Coat the tappets with oil and insert into the tappet holes.



NOTE: Assemble the tappets in their original positions, paying careful attention to the cylinder numbers and intake and exhaust groupings.

2-3. **Insert the camshaft**

(1) Coat the camshaft bearing section with oil and insert the camshaft into the cylinder block by tapping the shaft end with a plastic hammer.

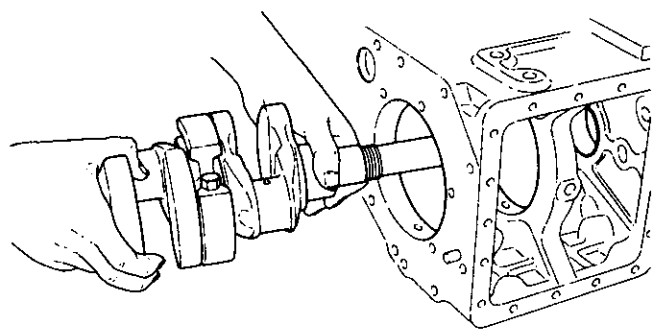


NOTE: Be careful not to damage the groove in the end of the shaft.

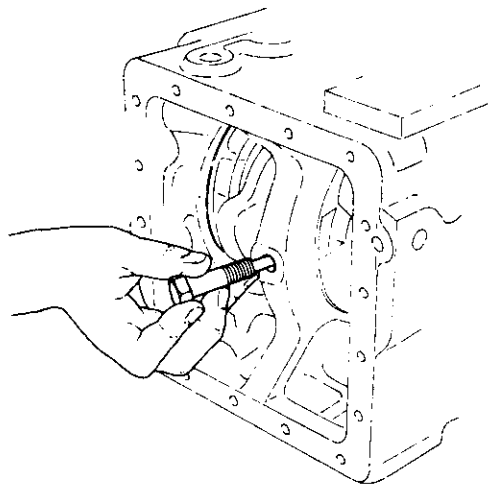
(2) After inserting the camshaft, check that it rotates smoothly before tightening the camshaft bearing set screw.

Tightening torque	2 kgf-m (14.5 ft-lb)

2-4. **Install the crankshaft**



2-5. Tighten the set bolt of the intermediate main bearing



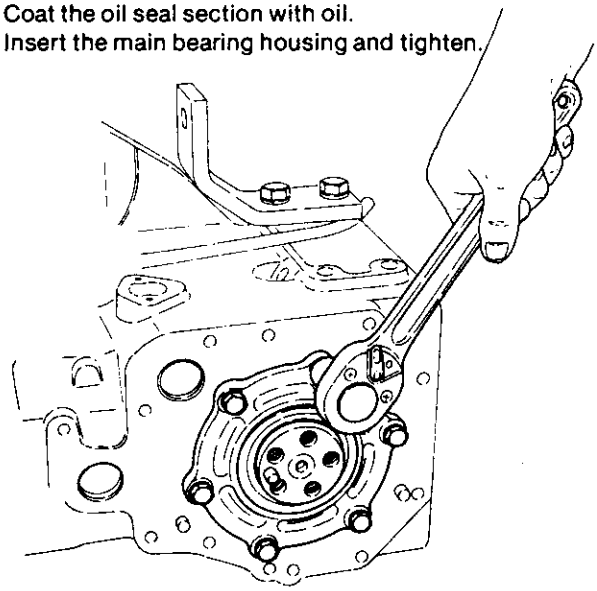
There are two intermediate main bearings, viz No.1 and No.2, for model 3GMF Y .

kgf-m (ft-lb)

	2GMFY, 3GMFY
Tighten torque	4.5 ~ 5.0 (32.5 ~ 36.2)

2-6. Install the main bearing housing

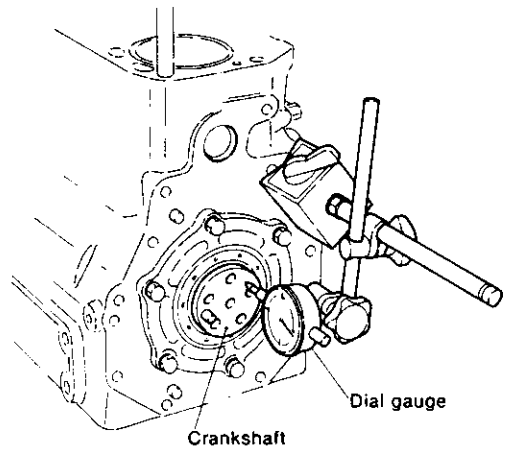
(1) Coat the oil seal section with oil.
(2) Insert the main bearing housing and tighten.



Tightening torque	2.5 kgf-m (18 ft-lb)

(3) Check that the crankshaft rotates smoothly.

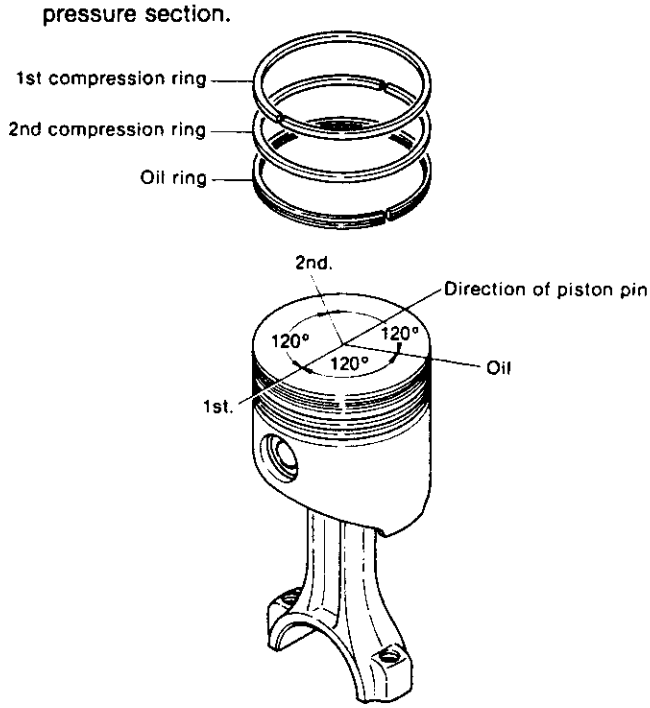
(4) Measure the crankshaft side gap, and adjust it to the prescribed value by the thickness of the packing.



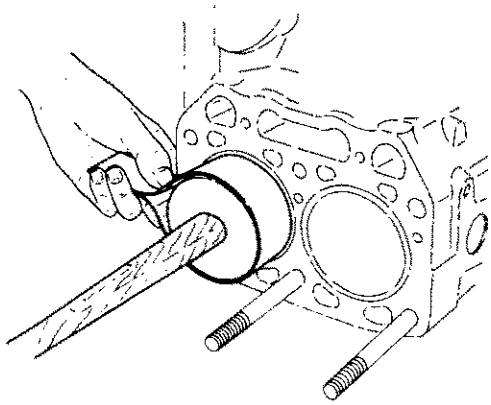
Crankshaft side gap	0.09 ~ 0.18mm (0.035 ~ 0.0071in.)

2-7. Assemble the piston and connecting rod assembly

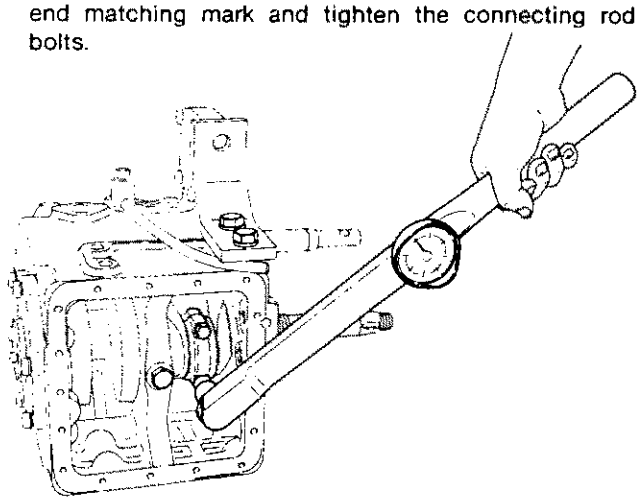
(1) Coat the crankpin section with oil and position so that the insertion side crank is at the top.
(2) Coat the piston and crankpin bearing with oil.
(3) Position the piston rings so that the gaps are 120° apart; make sure that there is no gap at the side pressure section.



(4) Insert the piston connecting rod assembly so that the side of the connecting rod large end with the identification number is on the exhaust side.
Install the piston rings with a piston ring inserter.



(5) After the connecting rod large end contacts the crankpin, push the piston crown down slowly to turn the crankshaft to bottom dead center.
(6) Align the connecting rod cap and connecting rod large end matching mark and tighten the connecting rod bolts.



CAUTION: 1. Be careful to tighten the connecting rod bolts evenly.
2. Coat the bolt threads and washer face with oil.

	kgf-m (ft-lb)
	2GMFY, 3GMFY
Tightening torque	2.5 (18.1)

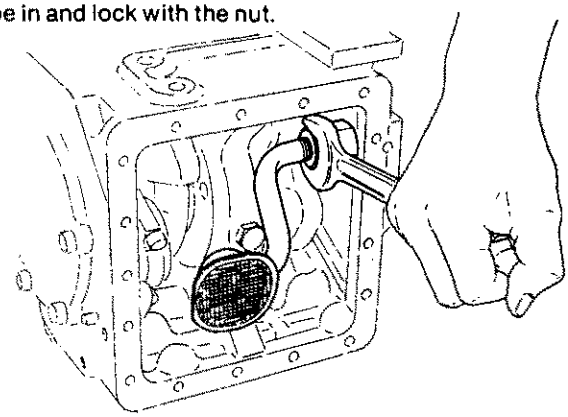
(7) Measure the side clearance

Side clearance	0.2 ~ 0.4mm (0.0079 ~ 0.0157in.)

(8) Check that the crankshaft rotates smoothly.

2-8. Install the lubricating oil intake pipe

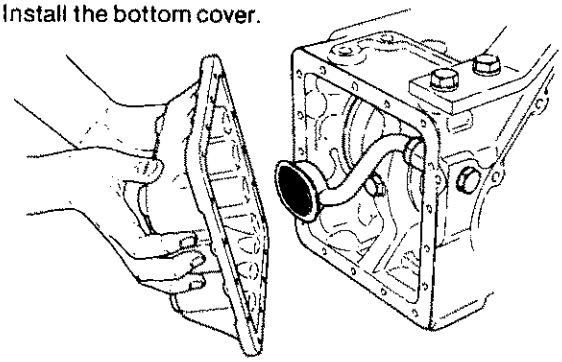
Coat the threads with "Screw Lock Super 203M", screw the pipe in and lock with the nut.



Screw-in distance	8 ~ 10mm (about 6 turns) (0.3149 ~ 0.3937in.)

2-9. Install the engine bottom cover (oil pan)

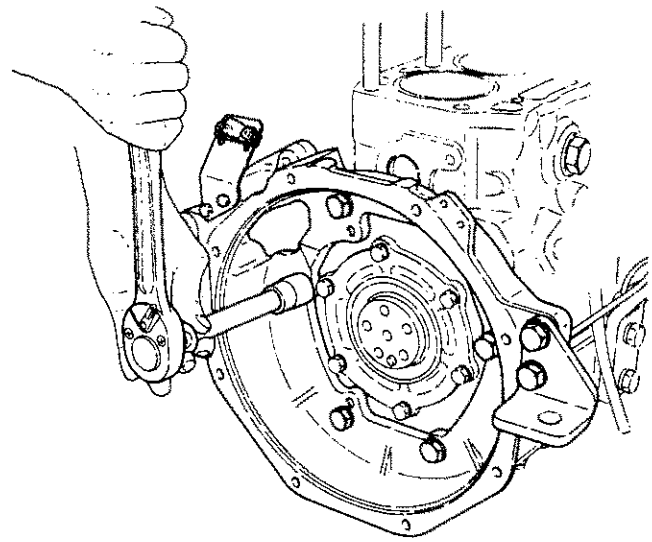
(1) Change the packing.
(2) Install the bottom cover.



Tightening torque	0.9 kgf-m (6.5 ft-lb)

2-10. Install the mounting flange

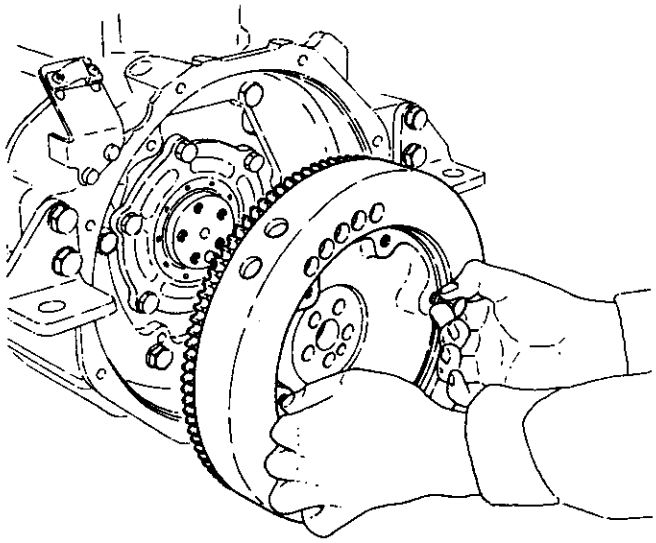
(1) Set the engine upright.
(2) Align the positioning pins and tighten the flange.



Tightening torque	4.5 kgf-m (32.5 ft-lb)

2-11. Install the flywheel

(1) Align the reference pins.
(2) Install the flywheel.



Tightening torque	6.5 ~ 7.0 kgf-m (47 ~ 50.6 ft-lb)

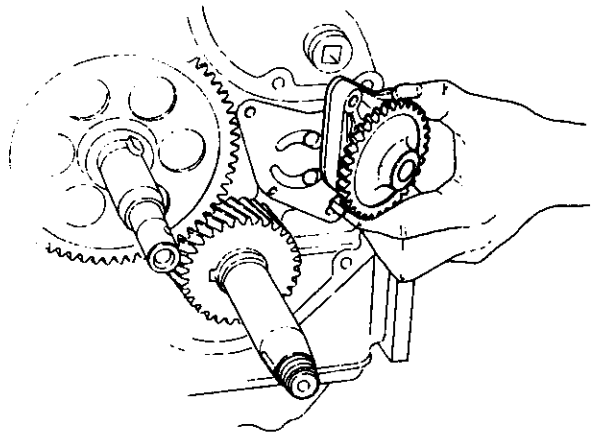
NOTE: After tightening, check the end run-out.

2-12. Install the engine feet and set the engine in position

(1) Dipstick flange and dipstick.
(2) Fuel pump.

2-13. Install the lubricating oil pump

Install the lubricating oil pump and driving gear assembly.

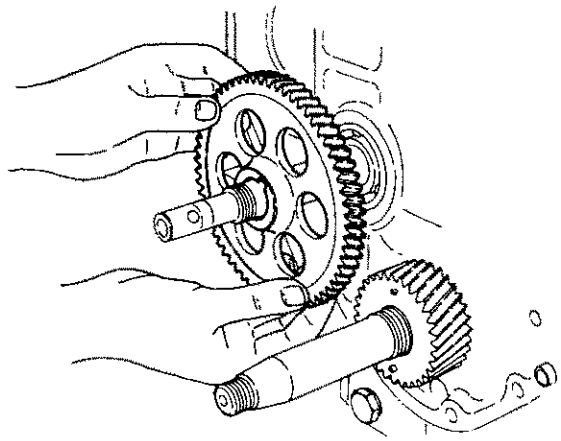


Lube pump body mounting bolt	0.9 kgf-m (6.5 ft-lb)

2-14. Assemble the camshaft gear and fuel cam

(1) Coat the shaft hole of the camshaft gear with oil and insert the gear.

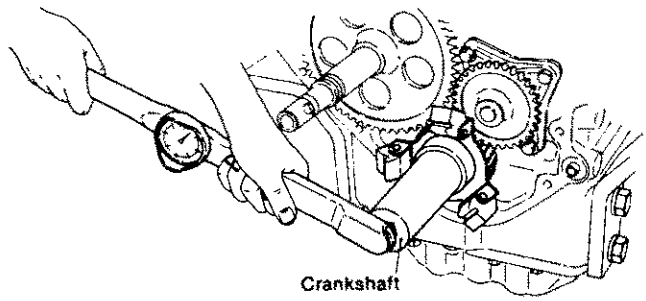
(2) Coat the fuel cam with oil and insert the cam by aligning the "0" mark opposite the camshaft gear.



(3) Tighten the camshaft end nut.

Tightening torque	7 ~ 8 kgf-m (50.6 ~ 57.9 ft-lb)

2-15. Assemble the crankshaft gears



(1) Coat the crankshaft section and the inside of the gear with oil.
(2) Align the matching marks of the camshaft gear and the crankshaft gear and insert the crankshaft gear.
(3) After inserting the crankshaft gear, check the backlash.

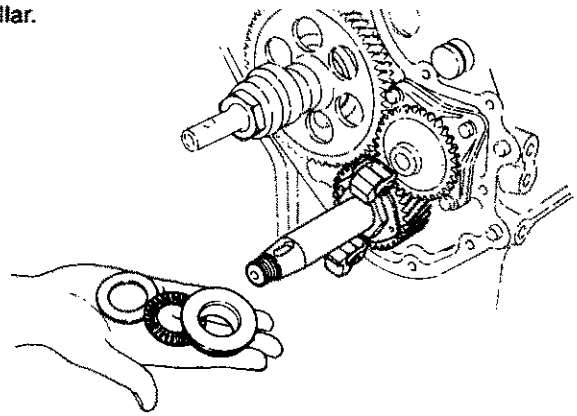
Backlash	0.05 ~ 0.13mm (0.0020 ~ 0.0051in.)

(4) Install the governor weight assembly and tighten the crankshaft end nut.

Tightening torque	8 ~ 10 kgf-m (57.9 ~ 72.3 ft-lb)

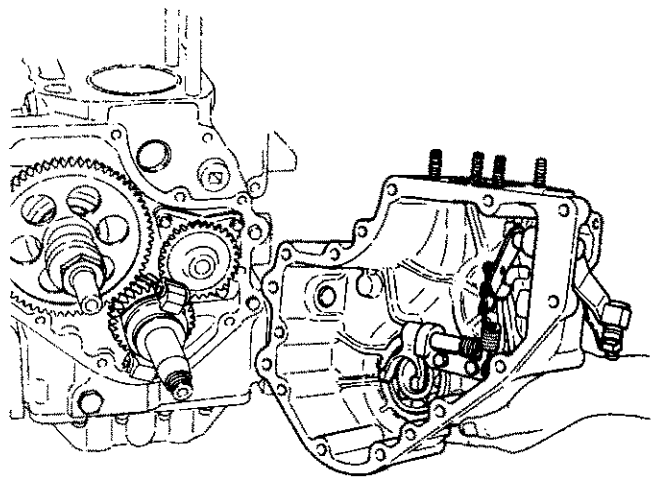
2-16. Install the governor sleeve

Install the governor sleeve, thrust needle bearing and thrust collar.



2-17. Install the timing gear case

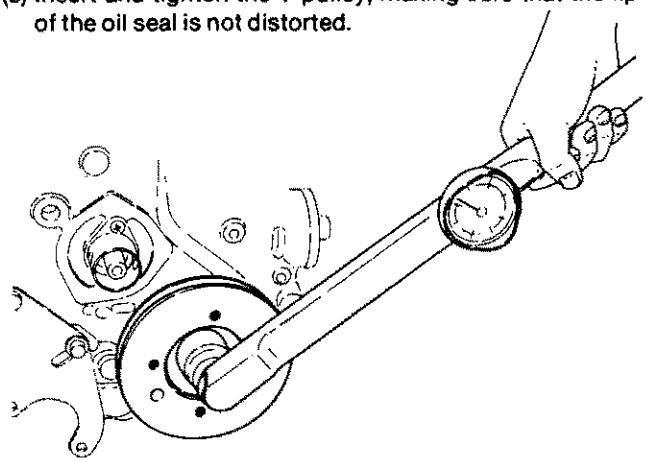
(1) Coat both sides of the new packing with "Three Bond 3B8-005" and install.
(2) Install the timing gear case.



Tightening torque	2.5 kgf-m (18 ft-lb)

2-18. Install the crankshaft V-pulley

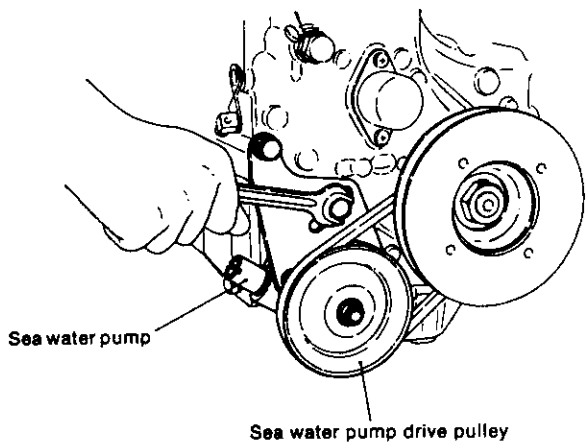
(1) Install the crankshaft key.
(2) Coat the crankshaft V-pulley and the inside of the oil seal with oil.
(3) Insert and tighten the V-pulley, making sure that the lip of the oil seal is not distorted.



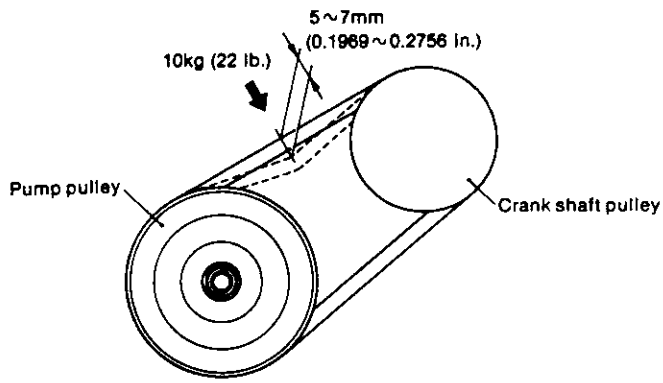
Tightening torque	10 kgf-m (72.3 ft-lb)

2-19. **Install the water pump**

Install the V-belt to the crankshaft V-pulley and install the water pump.



(1) V-belt tension

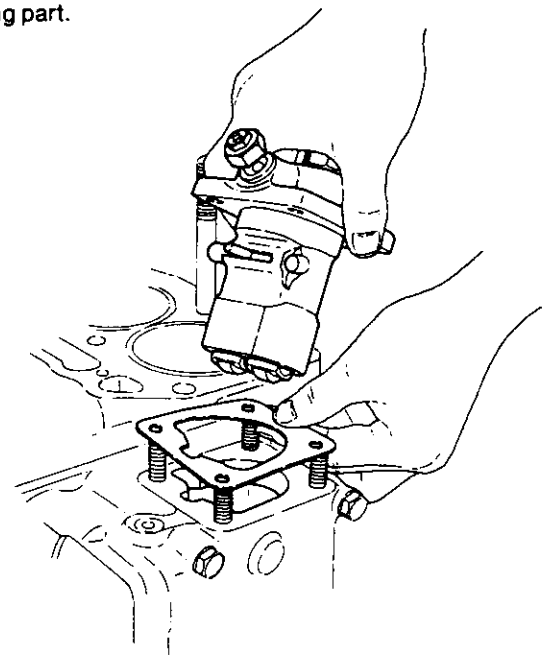


V-belt tension Pushed with a force of 10kg (22 lb.)	5 ~ 7mm (0.1969 ~ 0.2756 in.)

(2) Tightening torque.

Tightening torque	2.5 kgf-m (18 ft-lb)

(3) Insert the pump by looking through the gear case side cover, and align the governor No.2 lever and rack connecting part.



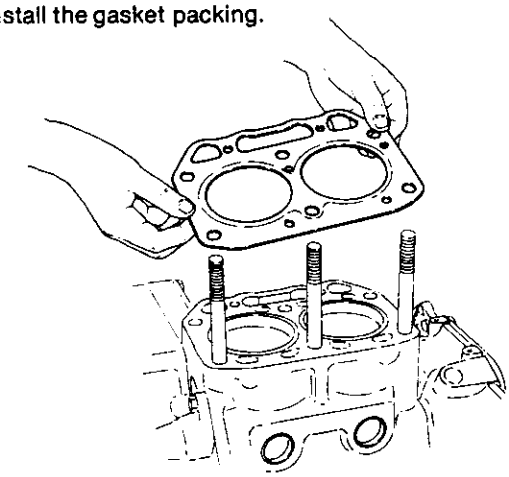
(4) Tighten the fuel pump

Tightening torque	2.5 kgf-m (18 ft-lb)

(5) Install the gear case side cover.

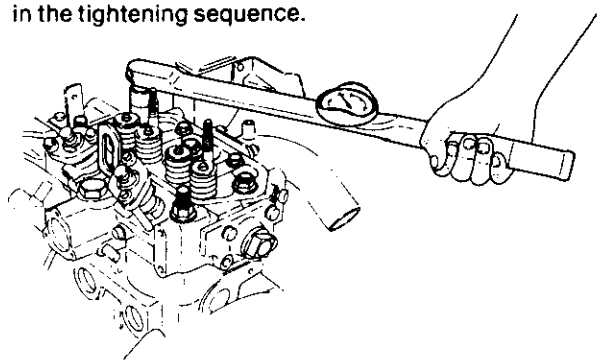
2-20. **Install the cylinder head**

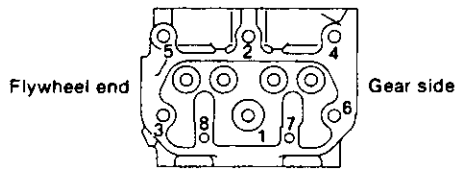
(1) Install the gasket packing.

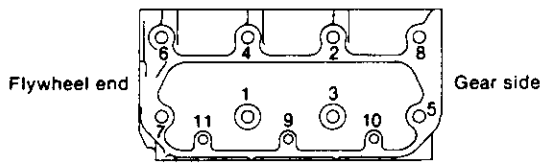


CAUTION: Take particular notice of the surfaces to be fitted.
Keep the TOP mark on the cylinder head side.

(2) Insert the cylinder head, being careful not to damage the threads of the tightening bolts, and tighten the nuts in the tightening sequence.







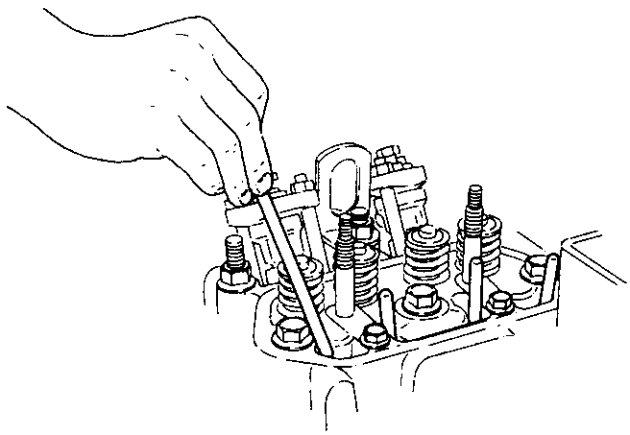
kgf-m (ft-lb)

Tightening torque	Main	10 (72.3)
	Sub	2.5 (18.1)

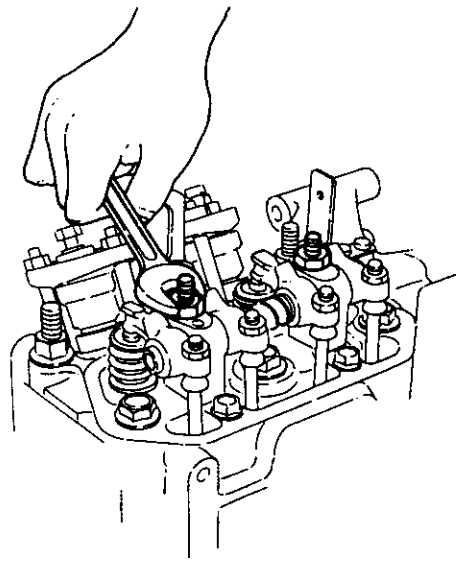
(3) Install the water pipe
(from the thermostat cover to the cylinder inlet joint).

2-21. Install the rocker arms

(1) Install the push rods on the tappets.



(2) Coat the inside of valve spring retainer with oil.
(3) Install the rocker arm shaft assembly and tighten the nut.



Tightening torque	3.7 kgf-m (27 ft-lb)

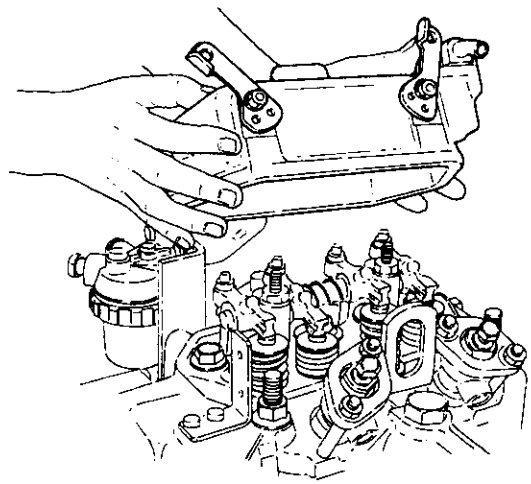
CAUTION: 1. Loosen the valve head clearance adjusting screw in advance.
2. Check that the arm moves smoothly.

(4) Adjust the intake and exhaust valve head clearance and lock with the nut.

Intake and exhaust valve head clearance (engine cold)	0.2mm (0.008in.)

2-22. Install the rocker arm cover

(1) Install the rocker arm cover.

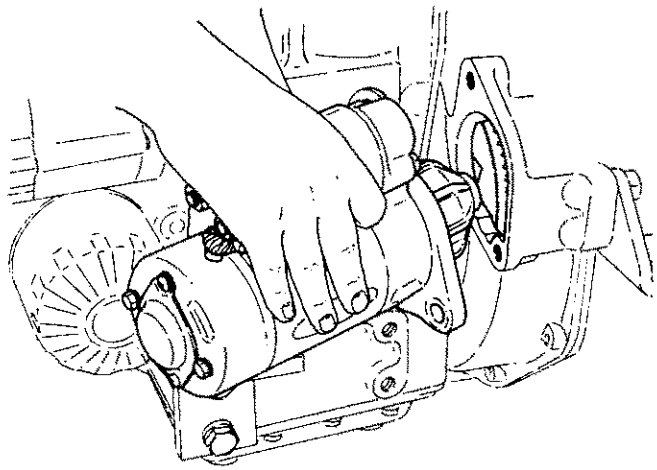


(2) Install the breather pipe to the air intake pipe (intake manifold...3GMFY).

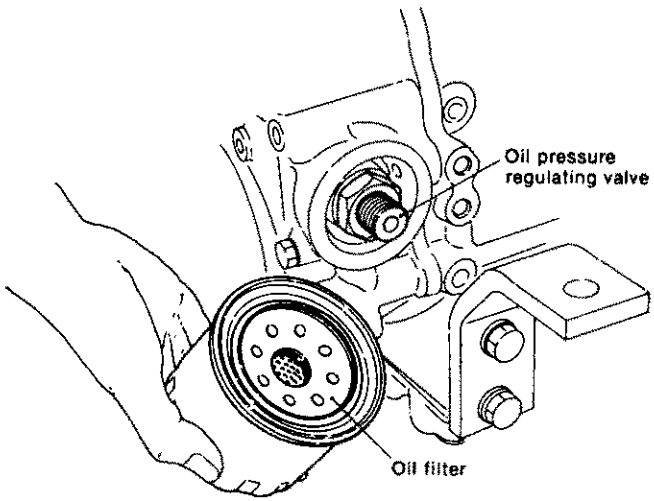
3. Accessaries

The following sequence is different from that of a sea water-cooled engine.

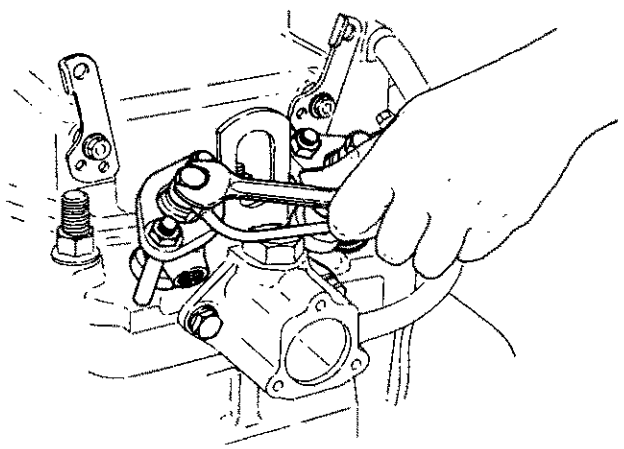
3-1. Install the starter motor



3-2. Install the oil filter

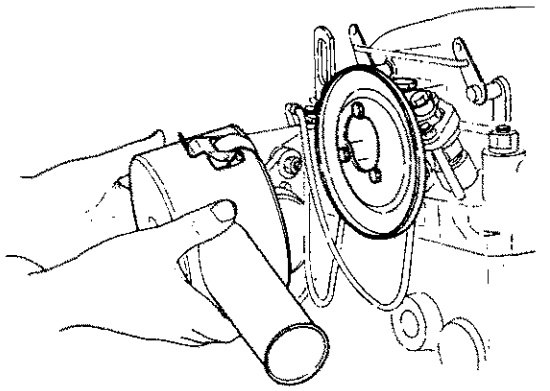


3-3. Assemble the high pressure fuel pipe and fuel return pipe



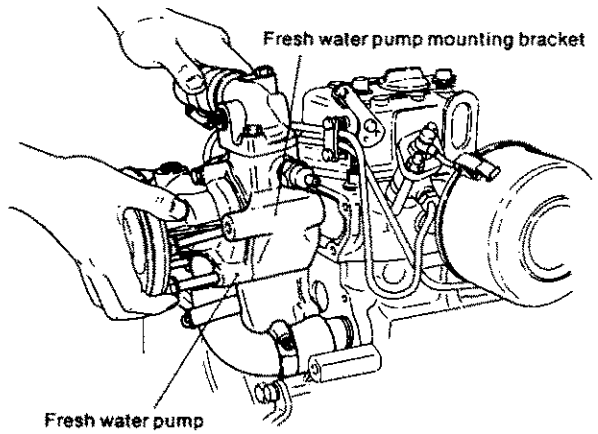
3-4. Install the intake silencer

(1) Install the intake silencer cover to the air intake pipe. [intake manifold...3GMFY]
(2) Install the intake silencer and tighten it with the clip.



3-5. Assemble the CFW pump

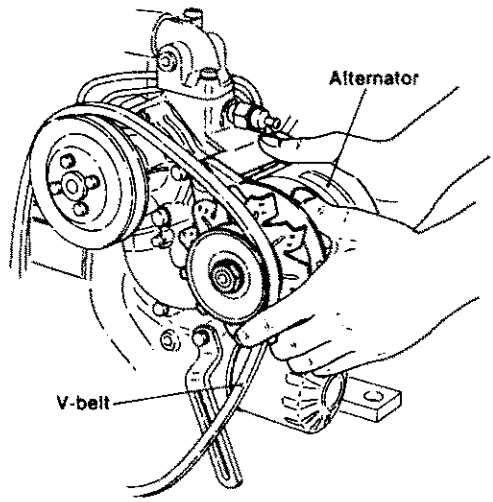
Mount the CFW pump and replace the CFW hose between the CFW pump and cylinder block by connecting at the CFW pump and at the cylinder block.



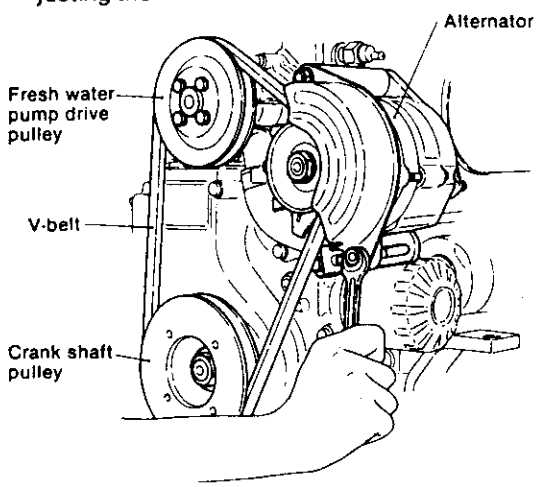
Tightening torque for CFW pump fixing bolt	2 ~ 2.5 kgf-m (14.5 ~ 18 ft-lb)

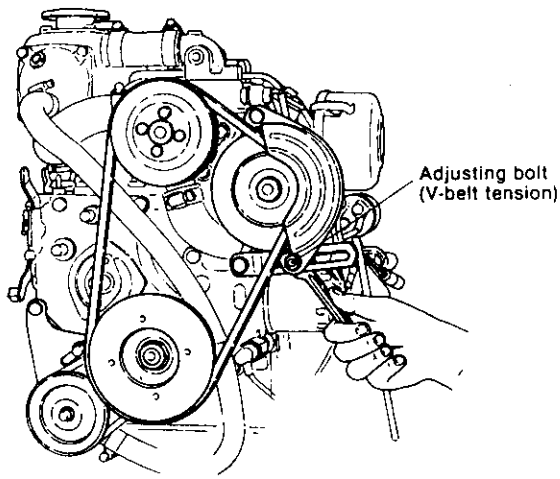
3-6. Install the alternator

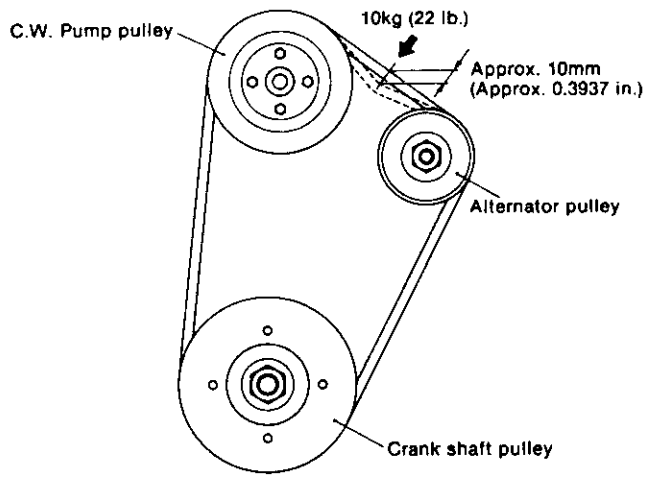
(1) Install the alternator to the bracket.



(2) Install the V-belt and tighten the adjusting bolt while adjusting the V-belt tension.



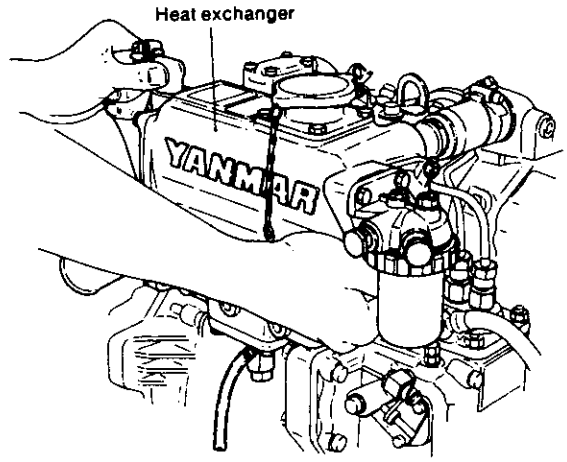




V-belt tension Pushed with a force of 10kg (22 lb.)	Approx. 10mm (Approx. 0.3937 in.)

3-7. **Assemble the heat exchanger**

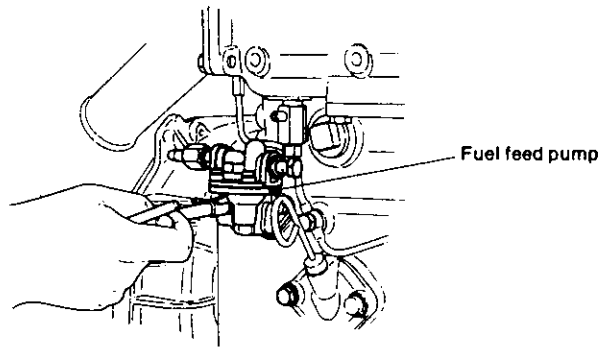
Mount the heat exchanger and replace the CFW hose at the thermostat cover side by connecting the hose to the heat exchanger. Tighten the hose clamp after the heat exchanger is assembled.



Tightening torque for heat exchanger fixing bolt	2 ~ 2.5 kgf-m (14.5 ~ 18 ft-lb)

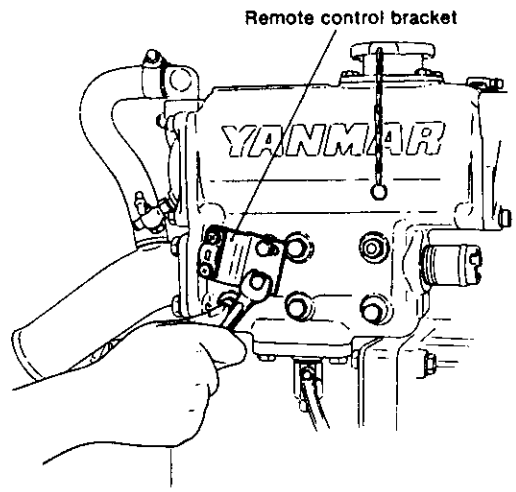
3-8. **Assemble the fuel feed pump** (3GMFY)

For model 3GMFY engine assemble the fuel feed pump after the heat exchanger is assembled.



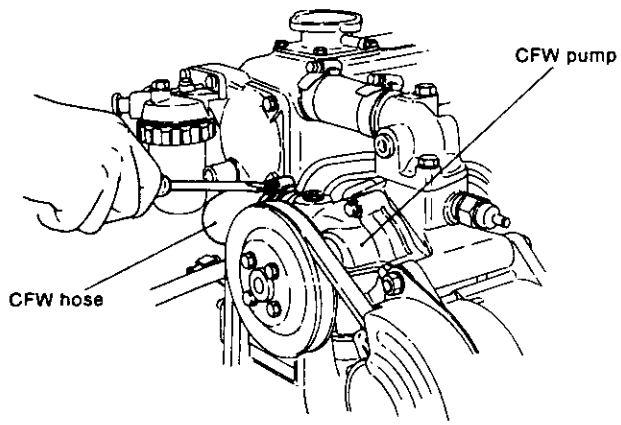
3-9. **Assemble the fuel oil pipe**

(1) Fuel feed pump—fuel filter
(2) Fuel filter—fuel injection pump

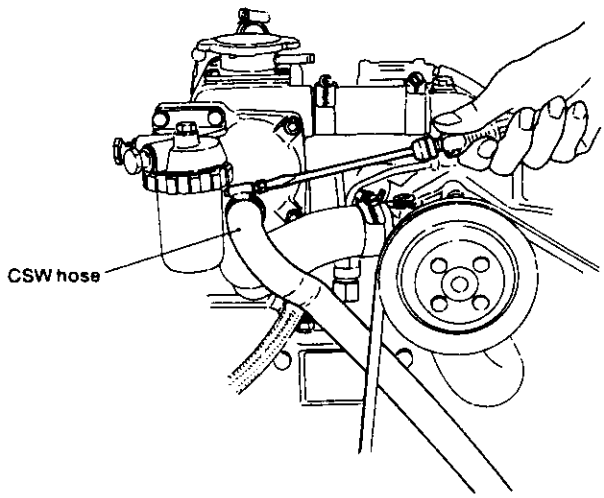


2-10. Assemble the cooling water pipe

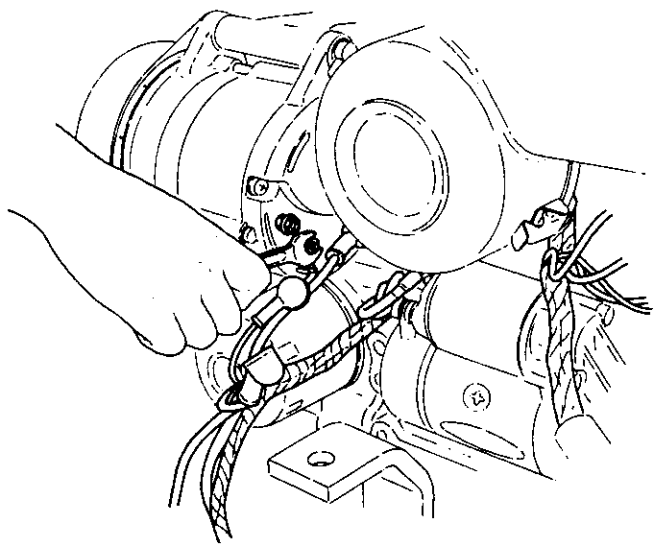
(1) CFW hose (heat exchanger—CFW pump)



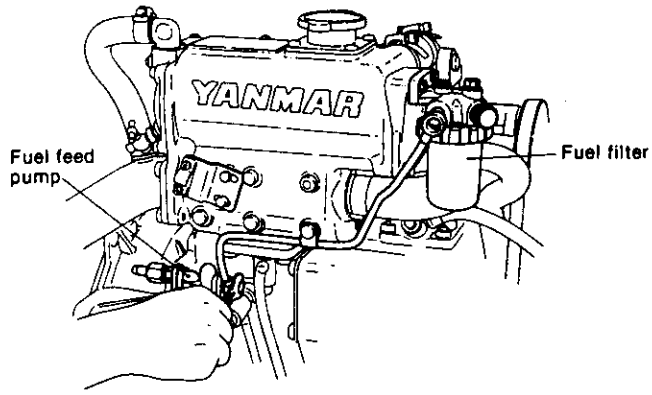
(2) CSW hose (CSW pump—heat exchanger)

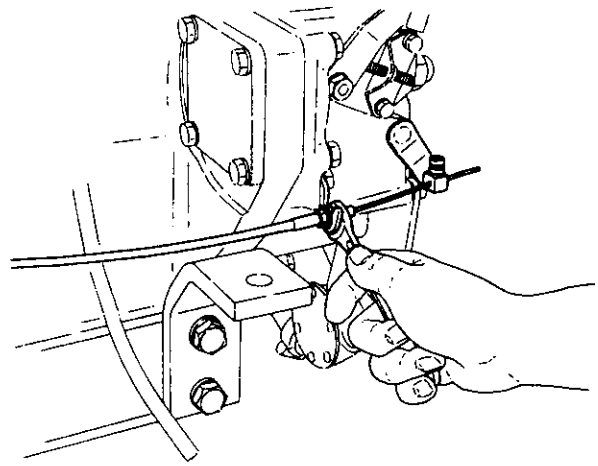


2-11. Connect the electrical wiring



2-12. Install the remote control cables





2-13. Connect the interior piping

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